Longitudinal relationships between phonology and the lexicon in typically developing toddlers and late talkers: A psycholinguistic perspective.

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Abstract

Background: Research spanning more than two decades has emphasised the lexical deficits of late talkers. However, late talkers have been found to have associated delayed phonological acquisition. Given the close connection between these two linguistic domains, it may be that the late language emergence often observed in these children, arises from deficits in their underlying phonological processing system. This thesis explored the longitudinal relationships between the phonological and lexical development in typically developing toddlers (TD) and those who fit the criteria of late talkers (LT), in light of a psycholinguistic speech processing framework.

Methods: The cohort comprised 168 children aged 2;0 (years; months) at intake who were reassessed when they were about 3;6 and 5;0 years, on measures of phonological accuracy and expressive language. Phonological accuracy (expressed in terms of a percentage of consonants correct) was used as the main behavioural indicator of children's phonological development and was measured in two conditions; in a test of nonword repetition (NWR), and a standardised picture naming/articulation test. Children's lexical development was assessed using standardised tests of language. Relationships between phonology and expressive language were derived based on correlation and regression analyses of groups' scores, as well as in the varied clinical profiles characterised by children's abilities in one domain of language relative to the other. With the dataset, analysis of concurrent correlations was conducted in order to identify and compare statistical significance between individual measures of phonological accuracy and the lexicon at each time-point for TD children and LTs. Regression analyses were conducted to identify the proportion of variance in expressive language explained by each measure of phonological accuracy in TD children and LTs. Differences between TD and LT groups in mean scores for phonology and expressive language at each time point were analysed to determine statistical significance.

Results and conclusions: Late talkers' performance on a range of measures was significantly different to that of their typically developing peers at all time points. Results indicated that the patterns of individual and combined relationships between phonological accuracy and expressive language also differed between TD and LT children across development. Sufficient phonological representations and motor programs were prerequisites for expressive language development at age 2;0. By age 3;6 and 5;0 continued vocabulary acquisition and expressive language development increasingly relied on their ability to employ phonological units for generating new / nonwords (i.e., the motor programming facility of their speech processing system).

The LTs were found to form a heterogeneous group with varied profiles across development. The emergence of subgroups of LTs and observed shifts in their patterns of phonological relative to expressive language over time, suggested differential underlying deficits in terms of access to different levels of the processing system depending on their phases of development and profiles at different ages. By age 5;0 although the early language difficulties for a majority of LTs resolved, more than half manifested delayed phonological development indicating persistent immaturity in motor programs. The corollary of persisting phonological difficulties in children is that it places them at risk for literacy difficulties at school age. Implications for clinical practice and research were discussed.

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For Isa and Ilyas,

"Do a little more than you're paid to.

Give a little more than you have to.

Try a little harder than you want to.

Aim a little higher than you think possible,

and give a lot of thanks to God for health, family and friends."

– Art Linkletter

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MSEL-VR..Mullen Scales of Early Learning - Visual Reception

PLS4....................Preschool Language Scale, Fourth Edition (Australian Language Adapted)

AC..Auditory Comprehension

EC..Expressive Communication

CELFP2 ....Clinical Evaluation of Language Fundamentals Preschool, 2nd Edition

RLI ....Receptive Language Index

ELI ....Expressive Language Index

LCI ....Language Content Index

LSI ....Language Structure Index

EV ....Expressive Vocabulary

RS ....Recalling Sentences

TPT ....Toddler Phonology Test

DEAP ....Diagnostic Test of Articulation & Phonology

TENR-R ....Test of Early Non-word Repetition-Revised

PCC ....Percentage of Consonants Correct

PIPA ....Primary Inventory of Phonological Awareness

SSeg...Syllable Segmentation

RA...Rhyme Awareness

AA...Alliteration Awareness

PI...Phoneme Isolation

PS..Phoneme Segmentation

SS...Standard Score

CHAPTER 1 INTRODUCTION

While there have been few studies on the longitudinal relationship between phonology and the lexicon involving late talkers, questions remain about the psycholinguistic processing mechanisms that underpin phonological development and how children's strengths and weaknesses in processing may affect the lexical-phonology interaction. The overarching aims of this thesis are to examine the nature of these relationships, track their trajectories over time and explore underlying deficits that contribute to the early delay in expressive language and persisting impairment.

One of the most common reasons that young children are referred to health care providers for evaluation is due to expressive language delay (Ghassabian et al., 2014; Whitehurst & Fischel, 1994). Expressive language delay may be a secondary sign of a range of developmental disorders such as intellectual disability, learning disability, autism spectrum disorder, attention deficit hyperactivity disorder, specific language impairment, and so on (Rescorla, 2011). However, an estimated 10-15% of young children known as 'late talkers' evidence slow onset of word development and phrases, compared to their peers, despite the absence of such developmental diagnosis or deficits (Rescorla, 2011).

Over the last three decades research has sought to improve methods of identification, descriptions of characteristics, outcomes and underlying causes for late talking, as well as knowledge of risk and predictive factors for both short- and long- term outcomes (Rescorla, 2011). The quest for early characteristics that would reliably predict longer term outcomes has been hampered by the fact that 'late talkers' do not form a heterogeneous group (Desmarais, Sylvestre, Meyer, Bairati, & Rouleau, 2008; Hawa & Spanoudis, 2014). While findings are currently varied, environmental and genetic factors and the interactions between them have been found to be strong predictive factors affecting young children's language development (Reilly et al., 2010; Rescorla, 2011) but prediction accuracy is still tenuous.

To date, few studies have addressed the role of phonology in accounting for the slower acquisition and learning of words in late talkers or later language outcomes. Given the persistent delay in phonological development in a portion of late talkers (Paul & Jennings, 1992; Roberts, Rescorla, Giroux, & Stevens, 1998), the addition of phonological measures may better predict whether a late talker will later resemble a child with typical language development or a child with persistent language impairment.

Because language development is a foundational factor underpinning later educational, academic, social, emotional and behavioural development, close examination of early relationship between phonology and expressive language could lead us to specific intervention strategies that could limit, if not prevent, the detrimental impact of early weaknesses in language development. Continued investigations will provide invaluable information for various stakeholders. From clinical, educational, community and governmental viewpoints, it is advantageous to predict early which children will have difficulties with later achievements.

Chapter 2 begins with a brief overview of the general patterns of young children's phonological and lexical development. Knowledge of the developmental path in the processes of phonological and language acquisition influences clinical assessment of children at risk for phonological and language impairments. Hence, this overview aims to set the context for the subsequent discussion on late talkers. This is followed by an overview of selected studies comparing late talkers' and typically developing young children's phonetic and phonological characteristics as well as the cognitive processes underpinning acquisition. Findings reported by these studies were synthesised drawing attention to the main theoretical concepts or hypotheses raised by the different investigators to explain the interplay between phonology, lexical size and various mechanisms of language acquisition.

Subsequently in Chapter 3, the psycholinguistic assessment framework of Stackhouse and Wells (1997) was identified as an approach that befits the aim to elucidate understanding of underlying cognitive processes and their impact on surface speech production. An overview of the Stackhouse and Wells (1997) speech processing model, the speech processing profile and the developmental phase model of this framework is presented. These chapters set the stage for introducing and describing the present study in Chapter 4 where research aims, rationale, questions, and hypotheses are outlined in light of the findings identified by the overview.

Chapter 5 discusses the methodological considerations undertaken that served to inform decisions on research methods delineated in Chapter 6. The themes of the current study are examined through a longitudinal design that allows for participants' phonological and language development to be tracked over time, at the ages of two, three-and-a-half, and five years old. Chapter 6 describes the method, and outlines how the results from assessment instruments would be used to interpret children's processing mechanisms from the psycholinguistic perspective that is, which channels and levels of processing within the psycholinguistic framework are tapped by the different measures used in the current study. Procedures for data collection and analyses are described as are conventions for transcribing and scoring. The chapter ends with the diagnostic steps taken to ensure that the data set is valid for statistical analyses.

In Chapter 7, results of descriptive statistics, correlation, and regression analyses are outlined, followed by a presentation of findings organised according to the research questions set. Finally, Chapter 8 discusses these findings in light of the patterns of commensurate and dissociated development between various measures across subgroups. The relationships between phonology and expressive language development, as well as relative contributions of phonological systems on language outcomes are also discussed. The thesis concludes with a reflection of research limitations, strengths, and implications for clinical practice and future research.

CHAPTER 2 PHONOLOGY AND THE LEXICON

One of the most amazing achievements of early childhood is the acquisition of speech and language. Infants acquire language by integrating their perceptual, articulatory and linguistic systems. In infancy speech perception paves the way for speech production and subsequently toddlers continuously refine their articulatory skills at different stages of their development. By age 5;0 (years;months), typically developing children have adequately mastered their system of speech sound production, acquired words in the thousands and become skilled at constructing grammatically age-appropriate sentences for the purpose of basic interactions. Nevertheless, there is substantial variation in the rate of children’s development in various domains of language. This section begins with a brief overview of the general patterns of young children’s phonological and lexical development separately as independent domains in order to set the context for subsequent discussion on late talkers.

2.1 Early phonological development

Phonology is the means for conveying meaning through speech during communication. Early phonological development progresses from pre-speech cries, vocalizations, and canonical babbling, prior to the development of meaningful words. Infants’ first words have been found to share the same consonants, vowels and syllables as their babblings (Stoel-Gammon, 2011). The speech production of children in the first 50-word stage is impacted by their physiology, child-specific strategies, and ambient language. This stage is also characterised by individual variations in pronunciation patterns of early word production in terms of the phones used, the variability of phonetic production and inconsistency of error types. This first 50-word stage is estimated to end between 18 to 24 months when rapid gains in phonology and other areas of language are observed. At 24 months, children evidence simple phonotactics, syllable shapes and sound classes, such that people unfamiliar to them can understand at least half of what they say (Stoel-Gammon, 2011). The phonotactics of the words in the ambient language also influence speech sound production. The speech productions of young children exposed to and learning English have been found to reflect the phonotactic probabilities (the regularity with which a sequence of phonemes is found in words) of the lexicon of English (Storkel, 2009; Zamuner, Gerken, & Hammond, 2004).

Large-scale cross-sectional studies on the acquisition of English (and varieties) have revealed a general trend in the phonological development of typically developing children between two and six years of age. For example, in a study on two-year-old children acquiring American English (Stoel-Gammon, 1985, 1987) it was reported that their phonetic inventories comprised labials (voiced and voiceless), stops (alveolar velar), nasals (labial and alveolar), glides, fricatives ([f] and [s]) as well as consonant clusters in word-initial and final positions. Their word structures included open and closed syllables usually in the form of disyllabic words. By age three, their phonetic inventory had expanded considerably to contain consonants of all place, manner and voice classes, as well as to include diverse syllable and word shapes.

Similarly, in a cross-sectional study Dodd, Holm, Hua, and Crosbie (2003) presented extensive normative data for the phonological development of about 700 British children exposed to only English aged between 3;0 and 6;11 years assessed at six-month intervals and divided into nine groups. Children's speech production abilities were assessed using two subtests from the Diagnostic Evaluation of Articulation and Phonology (DEAP) which was a single word naming or imitation picture test (Dodd, Hua, Crosbie, Holm, & Ozanne, 2002). The speech sounds (except for non-dialectal phonetic errors) were regarded as acquired if they were correctly produced by 90% of the children in each age group. With this criteria they found that stops, nasals, fricatives /f, v, s, z, h/, glides /w, j/ and word-initial /l/ were acquired by age 3;5, and affricates /ʧ, ʤ/, and fricative /ʒ/ between ages 3;6 and 3;11. Between 4;0 and 5;0, the fricative /ʃ/ was added to the children's repertoire. Both fricatives /θ/ and /ð/ and /ɹ/ were among the sounds acquired after the age of 6;0. Amongst the children in the oldest age group the boys produced lower accuracy than girls, while no gender differences were noted in the younger group. Socioeconomic status did not have significant effects on any of the measures of phonological accuracy.

In a separate study, Dodd and McIntosh (Dodd & McIntosh, 2010) evaluated the phonological acquisition of 62 Australian toddlers between the ages of 2;1 and 2;11, based on a collection of speech samples elicited using the Toddler Phonology Test (TPT; a single word naming or imitation test). They found that children aged between 2;1 and 2;6 had acquired consonant repertoires that comprised 10 sounds, /m, n, p, b, t, d, k, g, s, w/, accurately in 90% of occurrences; whereas those in the older group (2;7 and 2;11) produced 6 additional sounds, /ŋ, z, f, l, j, h/, accurately in 90% of occurrences. More than 25% of the children did not produce consonants / ʃ, θ, ʧ, ʤ, r / either correctly or as a substitution for another sound (ie. missing), while /ð, ʒ, v/ were not assessed. Ten of the children were assessed three times when they had reached three years, on another test of phonology. McIntosh and Dodd (2008) found a correlation between the children's performance on the TPT at the initial assessment with these subsequent assessments.

Large-group cross-sectional studies of typical acquisition such as these provide beneficial normative information by which to compare children and identify impairment. Although these studies utilized different methodological approaches which could have contributed to the variations in findings, much of the results reported broadly agreed with those described by McLeod and Bleile's (2003) review in terms of present and missing phonemes in children's phonetic repertoires (which ranged from 69.2–86.2 across the age range for Percentage Consonant Correct (PCC), the presence of clusters, as well as the complexity of syllable and words structures (presence of polysyllabic words).

The process of speech sound production has generally been described using models of speech motor control (A. Smith, 2006) and of language processing and production (Stackhouse & Wells, 1997). The focus of the present study is on the latter model which involves examining speech in phonetic and linguistic terms followed by an investigation of its manifestation in underlying psycholinguistic processing.

2.2 Early lexical development

Some children produce their first recognizable words as early as 10 months (Fenson et al., 1994). Longitudinal research shows that at the early stage, children's expressive vocabularies increase gradually at an estimated 10 new words per month before picking up speed as they approach their 50-word mark (Rescorla, Mirak, & Singh, 2000). The reported sizes of two-year-olds' productive vocabulary vary, with a mean of about 261.9 words for children learning Australian English (Bavin et al., 2008) and 307 words for children speaking American English (Fenson et al., 2007; Stoel-Gammon, 1991). Furthermore, according to Fenson and colleagues (2007), the normative data for 24-month-old children's expressive vocabulary on the MacArthur-Bates Communication Development Inventory (CDI) shows that a total vocabulary of 542 words reaches the 90th percentile, whereas the 10th percentile is 77. Among 24-month-olds, about 90% would have a minimum of 50 words in their expressive vocabulary and about 85% are combining words (Fenson et al., 2007). The use of word combinations or multi-word utterances thus signals the onset of syntax and acquisition of early grammatical morphemes, while their vocabularies continue to expand (Fenson et al., 2007). By 5 years old, children would have acquired more than 2000 words in their expressive vocabularies and use fully intelligible and complete sentences although not fully grammatically competent (Owens, 2012) .

Despite reported variations, there is a clear picture of the likely routes and rates of both phonological and lexical development for typically developing English-speaking children. Therefore, a delay in young children's acquisition of their ambient language within the typical time course by the age of 2 years is referred to as having an early language delay. An early language delay may be a secondary sign of diagnosed disabilities or deficits in cognitive, neurological, socio-emotional, motor or sensory domains (Rescorla, 2011). However, an estimated 10%-15% of children between the ages of 18 and 35 months - referred to as "late talkers" - evidence delayed vocabulary acquisition and the onset of word combinations despite the absence of such underlying pathology (Desmarais et al., 2008; Fenson et al., 2007; Rescorla, 2011).

2.3 Late talkers

Children described as 'late talkers' have been the subject of considerable research seeking to improve methods of identification, description of characteristics, outcomes, and underlying causes, as well as knowledge of risk and predictive factors for both short- and long- term outcomes (Rescorla, 2011). Predicting later language outcomes for these children remains as imprecise science and further investigations are warranted to provide invaluable information for parents, clinicians, educators, researchers and relevant funding bodies.

2.3.1 Identification

The main identifying characteristic of late talkers is their slow expressive vocabulary growth. In research, two of the most frequently used parent-report measures to differentiate late talkers from those with typical language development are the Language Development Survey or LDS, (Rescorla, 1989; Rescorla & Achenbach, 2002) and the MacArthur Communicative Development Inventory: Words & Sentences or MCDI:WS (Fenson et al., 2007). These checklists are designed to screen toddlers' expressive vocabulary, and have been found reliable in identifying those with expressive language delay (Fenson et al., 2007; Heilmann, Ellis Weismer, Evans, & Hollar, 2005; Klee et al., 1998; Rescorla, 1989). Despite differences in length and composition of words, significant correlations have been reported between the two instruments (Rescorla, Ratner, Jusczyk, & Jusczyk, 2005).

Studies have used different cut-offs points to identify LTs. For example, cut-offs of less than 50 expressive words (Paul, 1996; Rescorla, 1989), with or without two-word combinations at two years of age (Carson, Klee, Carson, & Hime, 2003; Klee et al., 1998; Thal, 2000), being at or below the 10^{th} percentile on a parent checklist of expressive vocabulary size (Dale, Price, Bishop, & Plomin, 2003; Ellis Weismer, 2007; Reilly et al., 2007) or performing more than one standard deviation below the mean on the Communication section of the Ages and Stages Questionnaire (Bricker & Squires, 1999; Zubrick, Taylor, Rice, & Slegers, 2007).

2.3.2 Characteristics

Compared to their typically developing peers, late talkers' acquisition of expressive vocabulary appears to be delayed by about 12 months. For example, Rescorla et al., (2000) reported that the late talkers in their sample had a mean expressive vocabulary size of 18 words at 24 months, based on the LDS, compared to the mean expressive vocabulary of 150–180 words by typically developing peers. In addition to this early expressive vocabulary delay, late talkers also manifest later onset of combining words (Carson et al., 2003; Mirak & Rescorla, 1998; Rescorla, Dahlsgaard, & Roberts, 2000) and later development of grammatical skills compared to typically developing peers (Dale et al., 2003; Rescorla & Achenbach, 2002; Thal, Reilly, Seibert, Jeffries, & Fenson, 2004) .

There is sufficient evidence from both small-scale and epidemiological studies for the association between late talking and various risk factors including being from families with history of late talking or learning difficulties, being male, having no or limited gesture use and delayed receptive language (Desmarais et al., 2008; Ellis & Thal, 2008; Paul & Roth, 2011; Reilly et al., 2007; Rescorla, 2011). Several investigations have identified two subgroups of late talkers based on receptive language status; those who exhibit concomitant receptive and expressive delay, and those with an expressive delay only (Ellis & Thal, 2008; Ellis Weismer, 2007; Leonard, 2009; Pharr, Ratner, & Rescorla, 2000; Thal, 2000). Prevalence estimates based on late talkers with delayed comprehension tend to be lower than those based on late talkers with expressive delay only (13.4% versus 19.1%; Zubrick et al., 2007).

Heterogeneity in other domains of development is also expected. Late talking has been associated with delayed phonological development (Carson et al., 2003; Mirak & Rescorla, 1998; Paul & Jennings, 1992; Rescorla & Ratner, 1996; Roberts et al., 1998; Thal, Oroz, & McCaw, 1995) and difficulties imitating novel words / nonwords (Ellis Weismer, 2007; Stokes, Catherine, & Anjali, 2013; Stokes & Klee, 2009b).

2.3.3 Preschool language outcomes

The term "late talker" is used to describe a characteristic rather than a clinical diagnosis or to refer to children as being *at risk* for language impairment rather than as being language impaired (Ellis & Thal, 2008; Stokes & Klee, 2009a). Despite the amount of research data accrued over the last 25 years on late talkers and their outcomes, describing their language patterns and identifying those whose language difficulties will persist has proven to be a challenging task (Hawa & Spanoudis, 2014; Roos & Ellis Weismer, 2008).

What can be learned from both small and large scale studies on the language development of late talkers thus far is that regardless of different cut-off points used, an estimated 40-80% of children with a history of late talking at age two have been found to "catch up" or develop language skills that fall within normal limits by age 3, 4, 5 and beyond, albeit at the low levels of performance (Paul, 1996; Rescorla, 2011; Rescorla, Roberts, & Dahlsgaard, 1997; Whitehurst & Fischel, 1994).

The children who 'caught up' and performed within normal limits on standardized tests, continue to evidence significantly weaker language skills compared to typically developing peers matched on age and SES. A sizeable remaining proportion of late talkers continued to evidence difficulties during the preschool and school age period and were subsequently diagnosed with Specific Language Impairment or SLI (Hawa & Spanoudis, 2014; Roos & Ellis Weismer, 2008).

Varying evidence for the strength of association between child- and family-related characteristics examined within the expressive language delay group at follow-up have been reported (Desmarais et al., 2008; Ellis & Thal, 2008). Similarly, predictors of language outcomes varied across studies. Small-scale longitudinal studies generally found few significant predictors of outcome and low positive predictive value from age 2, while large-scale epidemiological studies found varying significant predictors of outcome which included nonverbal IQ, and vocabulary at age 2, that explained at best about half of the variance in outcomes (Reilly et al., 2010; Rescorla, 2011).

Two late talker studies (Dale et al., 2003; Reilly et al., 2010) embarked on identifying the most suitable measure, or a combination of measures, that predicts the late talkers who would likely have persistent language impairment. Both studies used logistic regression to predict language outcomes at age four years but differed in terms of how they reported their regression results, criteria used for grouping and variables measured at age two years. Dale and colleagues (2003) entered non-verbal cognition, age, expressive vocabulary, use of communicative gestures, child's gender, and mother's level of education, as predictors in their regression model for predicting language outcomes. This model yielded a specificity of about 80% and a sensitivity of about 52% (about 20% of the children's language abilities did not resolve as predicted, and about half of the children did not show continuing language difficulties as predicted).

In the second study, Reilly et al., (2010) used a model comprising 12 measures of biopsychosocial factors as predictors which were only moderately successful in predicting low language performance at age four (AUC = 0.72 - 0.76). Late talker status at age 2 years was reported to improve the predictions slightly (AUC = 0.78 to 0.84). While they found that gender, being a fourth child, and family history of language problems were good predictors of delayed expressive language at age 4, coming from a Non-English Speaking home was the strongest predictor (odds ratio = 7.0).

Studies relating late talker status at age 2 to language outcomes at age 5 are lacking. Three studies considered relevant to this thesis are highlighted here. Although these studies differ in methodological approaches and design, they report similar findings in that children with a history of early late talking status continued to have significantly lower mean scores than their typically developing peers on an array of measures (Ellis Weismer, 2007; Moyle, Ellis Weismer, Evans, & Lindstrom, 2007; Rescorla, 2002).

Rescorla (2002) examined the development of language skills and the school achievement of late talkers (n=34) and typically developing children (n=25) matched on age, nonverbal ability and socio-economic status at intake. At age 5, 6% of the late talkers scored below the 10th percentile on a minimum of two subtests of the TOLD-2 (Test of Language Development-2, primary). Nonetheless, the late talkers had significantly lower means than typically developing children on vocabulary, grammar, verbal memory tasks and phonology (*d* > 0.85).

Moyle et al. (2007) investigated lexical and grammatical development in 30 late talkers who had been identified at the age of 2 as scoring below the 10th percentile on the CDI compared to 30 typically developing peers. At age five years and six months, even though most of the late talkers achieved scores within the normal range, they had significantly lower scores than typically developing peers matched on age, gender, nonverbal cognition, and socioeconomic status on measures of oral vocabulary (*d* = 0.97), grammatical completion (*d* = 1.46), and sentence imitation (*d* = 1.52) of the Test Of Language Development –Primary 3rd Edition (Newcomer and Hammill, 1997).

In another longitudinal study on late talking toddlers (n=40), Ellis Weismer (2007) found similar group differences in outcomes at age 5;6 on the TOLD-P3 Listening and Speaking Quotient compared to typically developing peers (n=43). The late talkers obtained significantly lower scores, especially in sentence imitation. At age 3;6 these children's scores on a fast mapping task at age 2;6 explained 36% of the variance in MLU (Ellis Weismer, 2007). Adding their scores for CDI and Preschool Language Scale-3 (PLS-3, Zimmerman et al., 1992) as predictor variables resulted in an increase to 65%. Age 5;6 prediction from age 2;6 using scores on the CDI, PLS-3, and nonverbal ability was weaker, but still accounted for 51% of the variance in TOLD-P3 scores.

More research is needed using additional variables, or even revisiting the examination of variables that have already been studied in order to further improve on the characterization of late talkers and the identification of predictors of outcomes. As mentioned in the overview of the general patterns of early phonological and lexical development at the start of this chapter, both phonology and the lexicon are subdomains of the linguistic system and hence are expected to be directly connected with each other. Few studies have focused on comparing late talkers with typically developing peers to characterize group differences on phonological measures and relating these to their vocabulary growth. The next section discusses examines the phonological abilities of late talkers.

2.4 Phonology in late talkers

Research in children's language acquisition has predominantly focused on individual domains of language such as the lexicon and phonology in isolation from each other, thus leading to a wealth of knowledge about how children acquire each of these domains of language separately (Stoel-Gammon, 2011). Studies that examined the relationship between early productive phonology and vocabulary in typical development have presented the notion that both domains of language tend to exist in a relationship (Stoel-Gammon, 1989, 2011). Among the earliest to support this view was Stoel-Gammon (1989) who found that the size of typically developing 2-year-old children's lexicon is related to the size of their phonetic inventory; leading the way for subsequent studies. Studies aiming to examine the relationship between these domains of language have involved varying groups of children: precocious, typical and late talkers. For example, Stoel-Gammon and Dale (1988) compared the vocabularies of 'precocious' infants age 1;6 with up to 600 words in their productive vocabularies to compared to same typical age-peers with and average vocabulary of 50 to 60 words, and found that the precocious talkers had larger phonetic repertoires at age 1;8 than the typically developing children at age 2;0. Precocious talkers' vocabulary sizes are also associated with the accuracy of their speech sound productions. Smith, McGregor, and Demille (2006) examined the spontaneous language samples of 'lexically precocious' children, and compared their phonological abilities to age-matched and older lexicon-matched children. The authors found that the lexically precocious group at age two had higher accuracy compared with age-matched peers and older children matched for lexicon size. Their findings revealed the rather than children's age, phonological development is more closely related to the sizes of their lexicons.

There is evidence that there is a relationship between phonological abilities in typically developing children and that a similar relationship exists for verbally precocious children. It would suggest that children who have limited vocabulary, such as children classified as Late Talkers would have poor phonological skills. In the next section, a series of studies looking at the phonological abilities in late talkers are described.

2.4.1 Speech-sound production in late talkers

Paul and Jennings (1992) compared the speech production phonological skills of typically developing children (n = 25) and late talkers (n = 28) matched on gender, age, and socioeconomic status. Three measures of speech-production were examined: the number of different consonants, the percentage of consonants correct, and the average level of complexity of syllable structure. These children were further grouped according to two age groups: (1) younger children who were 18 to 23 months of age in which late talkers were defined as those who produced fewer than 10 words, and (2) older children who were 24 to 34 months of age, in which late talkers were defined as those who produced less than 50 words or no two-word combinations.

The authors reported significant differences between the groups on the three speech-production variables. Specifically, they found that the older late talkers had poorer speech production as evidenced by significantly fewer different consonants (regardless of position). The phones in late talkers' inventories were those that typically occur earliest in the speech of typically developing children. While older late talkers also achieved lower mean percentage of consonants correct than typically developing peers they were comparable to that of the younger typically developing children's. Thus results showed that while their performance improved with age, older late talkers as a group had a lower percentage of consonants correct than their typically developing age peers but similar to that of younger typically developing children. Late talkers' pattern of phonological development resembled a delayed rather than atypical sequence and there was no evidence of significant change in the complexity of syllable structures over the time period studied.

Thal, Oroz, and McCaw (1995) examined the phonological and lexical development in a group of late talkers (n = 17) between 18 and 30 months old who scored below the 10th percentile for vocabulary on the MacArthur Communicative Development Inventory: Toddlers (CDI; Fenson et al., 2007). The late talkers were further divided into two groups: (1) meaningful speech group (MSG; n = 10), who produced a minimum of 10 different words and (2) the pre-meaningful speech group who did not (PSG; n = 7). The MSG group had relatively larger reported CDI vocabularies than the PSG, although the difference was not significant. They were comparable to the age- and language-matched typically developing groups in terms of volubility, but comparable to age-matched peers in terms of the number of word-initial consonants and in the maturity of syllable shape produced. On the other hand, the PSG group produced fewer vocalizations (regardless of intelligibility) compared to both control groups. They differed from their same-age peers on measures of word-initial consonants and maturity of syllable shape produced. Half of the children in the PSG group did not produce initial phones, whereas MSG children produced highly similar initial consonants to age-matched controls in more than 50% of their phonetic inventories. The use of final consonants by both late talkers groups differed significantly from that of their age-matched controls and children in the MSG group produced more final consonants than children in the PSG group. The authors concluded that late talkers who had large phonetic inventories and 10 or more words in their vocabularies made greater gains in lexical development than late talkers with small phonetic inventories and fewer than 10 words.

Rescorla and Ratner (1996) compared the phonetic inventories and vocalization and syllable formation patterns of late talkers (n = 30) they identified with Expressive Specific Language Impairment (SLI-E) and a control group of typically developing peers (n = 30) matched for age, SES and gender. The late talkers were defined according to their performances on the Reynell Receptive Language Scale (Reynell, 1977; scoring within four months of chronological age), the Language Development Survey (Rescorla, 1989; having fewer than 50 words including no word combinations), as well as on the Bayley Mental Development Scale (Bayley, 1969; having a score of more than 85 for Mental Developmental Index). They reported that the variables that most clearly distinguished 24 to 31 month-old children with late talkers from typically developing children were the rate of vocalization, the size of the consonantal inventory, and preferences on syllable-shapes. Specifically, the typically developing children were more voluble and evidenced a varied inventory of phonemes and syllable shapes. The late talkers, on the other hand, displayed significantly less frequent vocalisation, smaller inventories of consonants (primarily comprising voiced stops [b,d], nasals, glides, and [h]) and a greater proportional use of open syllables (single vowels only or consonant–vowel combinations). They found that late talkers' phonological characteristics resembled those of younger typically developing children, as had Paul and Jennings (1992), as opposed to atypical development.

In a follow-up study, the naturalistic speech samples of these children when they turned three were examined in order to determine their phonological gains (Roberts et al., 1998). These late talkers were compared to typically developing peers on measures of phonetic inventory, percentages of consonants correct, phonological processes, the rate of vocalizations, verbalizations, fully intelligible utterances, and mean length of utterance (MLU). They found that unlike at age two, there was no evidence of a significant difference between the groups in the number of vocalizations at age three. On the other hand, they found continued differences in the groups' phonetic inventories, percentage of consonant correct, and overall intelligibility. Consistent with earlier findings (Rescorla & Ratner, 1996), an analysis of the children's phonetic inventories showed that late talkers followed the same pattern of development as the typically developing group in most consonants.

Further evidence of speech-production difficulties in late talkers was evidenced in a longitudinal study (Pharr et al., 2000) comparing the syllable shapes produced by late talkers (n=20) who they also identified as SLI-E, to that produced by and typically developing peers (n=15) aged 24-36 months. According to detailed analyses, children with SLI-E produced relatively fewer syllable shapes which contained final consonants, more than one consonant type, and consonant clusters. At age 36-months, children with SLI-E produced approximately comparable proportion of syllable types as 24-month-old typically developing children. They also reported that the children with SLI-E vocalized less frequently. They posited that an expressive language delay is possibly based on phonological deficiency, given the phonological delays observed in these children's earliest productions. The overall findings of this study supported those reported by previous studies (Mirak & Rescorla, 1998; Paul & Jennings, 1992; Rescorla & Ratner, 1996; Thal et al., 1995) that children identified as slow to develop expressive vocabulary up to three years of age evidenced significantly different syllable structures compared to their typically developing age-peers. Unlike Thal et al's (1995) finding, this study found a significant difference between late talkers who used meaningful speech and age-matched controls. Similar to Thal and colleagues' study, Pharr and others also found that developmental stage had a significant effect; that late talkers who were at the prelinguistic stage of development performed significantly differently from their age-matched peers.

Unlike the studies cited above the following studies went a step further and examined whether there was also a predictive relationship of phonology and vocabulary on later language outcomes. For example, Mirak and Rescorla (1998) investigated the relationship between expressive vocabulary size and phonetic repertoire of late talkers or children that they also identified with SLI-E (n=37) between 24 and 31 months, and comparison typically developing peers (n=20) matched on SES, age, and nonverbal ability. Observations were conducted during five-minute long free-play sessions between mother and child, as well as structured administration of standardised tests (20 minutes). For both contexts, total number of consonants produced (tokens), the number of different consonants produced (types), inventory of consonants, and distribution of consonant use in different word-positions were measured. They compared the characteristics of children's phonetics with vocabulary size at intake and examined the predictive relationship between these variables at intake and language outcome twelve months later at age 3. Compared to the late talkers, typically developing children produced more consonant types (almost trebled) and consonant tokens (five times more). The number of types and tokens used by the typically developing group showed a positive but not significant correlation, while the correlation was strong and significant for the late talkers. This suggested that children with restricted vocabularies have similarly restricted repertoires in terms of both number and variety of phonemes, with both affecting the other. Although the late talkers' phonetic inventories were smaller overall than those of their typically developing peers, they showed similar patterns of acquisition; nine out of the ten most-used consonants were the same in both groups. This again indicated a delayed rather than atypical phonetic developmental pattern in the late talkers as in previously mentioned studies. Furthermore, the consonants most frequently used by the late talkers in this study were also comparable to Paul and Jennings's (1992) 24 to 34 months late talkers, as well as the MSG group (consonants produced in initial position) in the study by Thal and colleague's (1995). While consonant types and tokens were found to be significantly related to parent report of vocabulary size based on the Language Development Survey (Rescorla, 1989), the authors did not find a significant predictive relationship between these children's expressive vocabulary size or the phonetic repertoire at intake and language outcome when they were three years old.

Carson, Klee, Carson, and Hime (2003) conducted a one-year longitudinal study and investigated the phonetic and phonological developmental differences between children screened at age 24 months as late talkers (n=28) and their typically developing peers. Late talking was defined as having lesser than 50 words or no word combinations using the Delay Criterion 3 (Rescorla, 1989). The children's language ability was subsequently clinically evaluated within approximately a month using two measures: the Infant Mullen Scales of Early Learning (Mullen, 1989) and MLU (compared to group data by Miller & Chapman, 1981). These toddlers were then reassessed at age three using similar language scales and transcriptions of conversational interactions. The authors reported that children identified as late talkers (regardless of their language development on testing) had less complete phonetic inventories (consonant cluster types and numbers of different consonants) and simpler word shapes compared to their peers with typical language development. Based on the preliminary results of this study a late talker's risk for poor language development at age 3 depended on the level of delay in their early phonological development. Their results show further evidence of a connection between speech-sound production (as measured by phonological tasks) and late talking.

Williams and Elbert (2003) studied a group of five LTs between the ages of 22 and 31 months old. The LTs were defined as children whose expressive vocabularies contained less than 50 words, few word combinations (if any) based on parental report, and limited sound inventories (less than 15 sounds) at intake. They collected data via naturalistic and elicited speech samples from each child on a monthly basis for 10 to 12 months. The former was obtained during interaction between the child and an adult (parent and/or clinician) while they engaged in free-play. The latter was obtained during object naming opportunities to elicit sounds in word-initial and word-final positions. The phonological characteristics of children with persistent language delays were compared to those whose language delays resolved. According to the results of their study both qualitative (e.g., sound variability, error patterns, and rate of resolution) and quantitative (e.g., PCC scores, phonetic inventory, and number of sound errors), variables were potential markers of long-term phonological delay. In their review, Roth and Paul (2010) cautioned that the small sample size, and use of visual inspection of data only rather than statistical analysis deemed the level of evidence of the study as weak or the applicability of its results as limited.

More recently Vihman and colleagues (2013) analysed the phonetic and phonological characteristics of three groups of children, late talkers, 'transitional' late talkers and typically developers, who were at the end of the single-word period (using a criterion of twenty five different words in a thirty minute spontaneous sample), rather than grouped by chronological age as in Thal et al's (1995) study. Children were assessed on a percentage of consonants correct, the size of consonant inventory, the extent of consonant variegation, use of selected 'templates' (prosodic patterns) and volubility. The children were reassessed 14 months later on measures of phonology (percentage of consonants correct), the lexicon (diversity in types of function word and verb), morphology (obligatory morphemes) and syntax (MLUw and IPSyn). Children's performances on the phonology and language measures at the latter point were related to their earlier performances on the phonetic and phonological measures. High age at age 2;0, small consonant inventory and low phonetic variegation were strong predictors of low accuracy in consonant use and relatively poor lexicon, morphology and syntax at Time 2, explaining 34% of the variability. They also found significant correlation between reliance on a limited set of phonological patterns at age 2;0 and delayed morphological development at Time 2. This finding was also consistent with those of earlier studies' reviewed above and demonstrated that the transient late talkers' development was delayed rather than atypical compared to typically developing peers.

Varying methodological limitations such as small sample sizes and scoring differences have led the various authors to advise caution with the application of the results of their studies. Despite these methodological differences, studies on the phonological development of late talkers based on the above studies yielded similar findings:

1. Late talkers' phonological and lexical developments are commensurate

Similar to the studies on children with precocious and typically developing vocabularies, evidence from studies on late talkers presented a clear notion that their developing phonological and lexical systems tend to exist in a simultaneous relationship. Children with relatively limited phonetic repertoires had limited or smaller expressive vocabularies, whereas those with relatively complete repertoires had larger vocabularies. Taken together, approximately half of the children identified as late talkers at age two in these studies also continued to have both phonological and language delays at age three. Based on their findings it would seem reasonable to propose that there is a similar relationship between the phonological and lexical development of late talkers as in typically developing 2-year-olds, albeit delayed.

2. LTs may evidence delayed and/or atypical phonological characteristics.

Subsequent to acquiring their first words, late talking toddlers continued to be at a disadvantage in acquiring well-developed phonologies. As phonology developed, their phonologies were characterised by limitations in various aspects including the complexity in syllable structures, inventory of both vowels and consonants, percentage of consonants correct, and the number of consonant types produced (Mirak & Rescorla, 1998; Paul & Jennings, 1992; Rescorla & Ratner, 1996; Thal et al., 1995). For example, Thal and others (1995) reported evidence of resemblance of phonemic inventory and syllable structure in late talking toddlers to those of younger peers with comparable vocabulary sizes. At age 3, half of the children identified as late talker at age 2 continued to evidence restricted consonant inventories and percentage of consonants produced correctly (Rescorla & Ratner, 1998). The evidence from most of the studies reviewed suggest an overall pattern of delayed development rather than a qualitative difference from that of younger typically developing children (Mirak & Rescorla, 1998; Paul & Jennings, 1992; Rescorla & Ratner, 1996; Roberts et al., 1998; Thal et al., 1995; Vihman et al., 2013). Williams and Elbert (2003) on the other hand reported that qualitative variables could differentiate delay from atypical phonological characteristics.

3. There is evidence for relating early articulatory skills to late talkers' first words

In addition to knowledge of the speech sounds and their link to word meaning, speech production requires necessary articulatory and phonatory (speech-motor) skills for the production of words or the closest approximations possible of the adult forms. Children's early words have been observed to contain phonetic features that are acquired relatively early in the course of their phonological acquisition and there is an articulatory basis for the acquisition and growth of early vocabulary. Specifically, children's articulatory skills were hypothesized to have an influence over children's first words and the rate at which they acquire their first words (Pharr et al., 2000; Thal et al., 1995; Vihman et al., 2013).

Thal et al., (1995) reported that features found during children's pre-speech period have an influence over the first words acquired and the rate of vocabulary growth. Words that were difficult for children to produce were acquired later compared to words that contained sounds that were easier to produce. Similarly, Pharr et al., (2000) found a significant difference in syllable shapes as well as significant effect of developmental stage between prelinguistic late talkers and their age-matched peers. They cited earlier studies on how children's early words often comprise of syllable shapes (consonants and syllable shapes but not vowels) and production preferences found in later stages of babbling.

Specifically research into this continuity between canonical babbling and meaningful words revealed significant differences in the babbling patterns of late talking toddlers compared to their typically developing peers in terms of onset (Oller, Eilers, Neal, & Schwartz, 1999) and complexity (Fasolo, Majorano, & D'Odorico, 2008; Stoel-Gammon, 1989; Whitehurst, Smith, Fischel, Arnold, & Lonigan, 1991), and that these two factors were related to later lexical growth in toddlers even when cognition, comprehension and hearing were controlled (Oller et al., 1999; Whitehurst et al., 1991). This finding suggested that these children's delay in or lack of canonical babbling were likely due to poor ability to retrieve phonological representations as needed (Oller et al., 1999). These findings in general echoed an earlier study by Stoel-Gammon (1989) who reported evidence for the association between the lack of canonical babbles and a limited repertoire of consonants in the pre-speech period with delays in the development of meaningful speech of two late talkers.

4. There is evidence for relating earlier phonology to later language skills

Mirak and Rescorla (1998) found evidence for significant predictive correlations between consonant types and tokens and vocabulary size or late talker status. Williams and Elbert (2003) reported that qualitative variables could be useful predictors of later phonological delay. Carson et al., (2003) reported that a child's risk for poor language development (as measured by MLU and expressive vocabulary) at age 3 was higher the more delayed his phonological development was at intake. Taken together, approximately half of the children identified as late talkers at age two in these studies were found to have persistent phonological and language delays at age 3. Generally, the more delayed their phonological system was at age 2, the higher their risk for persisting delay in language with increase in age. The authors also indicated that phonological features and / or qualitative characteristics could be used to predict later language outcomes for young children with slow expressive language development.

5. Late talkers are less verbal than typically developing peers

Late talkers' pre-speech phonological characteristics and low volubility constitute two recurring themes in the studies cited. The authors found that while the volubility and language ability of the typically developing children in their respective studies developed concurrently, late talkers were found to be considerably less talkative in addition to having less developed phonologies and smaller vocabularies (Rescorla & Ratner, 1996, Pharr et al., 2000; Roberts et al., 1998; Vihman et al., 2013), although for some their volubility levels increased when they turned 3 years old (Roberts et al., 1998; Vihman et al., 2013). Accordingly, they suggested various hypotheses to explain this phenomenon. Central to their discussion was the notion of an interdependence of factors impacting and impacted by late talkers' volubility as well as the mechanisms of language acquisition in late talkers, which is discussed next.

6. There is interdependence between factors and mechanisms for language acquisition

Taken together, these studies indicated that while it was possible that late talkers' phonemic inadequacies were manifested in their small expressive vocabulary (i.e. limited phonetic skills negatively impact vocabulary acquisition), these two factors (phonetic and lexical) were attributed to the scarcity of their vocalizations thus reducing their opportunities for vocal practice, which was considered necessary to facilitate phonological development.

Vocal practice: Rescorla and Ratner (1996) postulated that the delay in the development of phonetic and phonological structure reflected late talkers' failure to utilise opportunities provided by vocal practice to facilitate phonetic development. Vihman and colleagues (2013) suggested that vocal practice can be considered to bootstrap the ability to match target sounds to articulatory patterns for sound production. The suggestion that vocal practice is a mechanism of language acquisition fits well with their findings if language is considered a motor skill. However, cross-linguistic studies on children's phonology and accuracy in repeating non-words have shown that articulation accuracy is not purely a motor skill (Hoff & Parra, 2011; Demuth, 2011). Based on their results Rescorla and Ratner also acknowledged that motoric inadequacy alone could not account for the fact that their late talkers were less verbal because they did not produce relatively more of the earlier-developing phonemes and syllable shapes in their vocalisations. Vihman and others further hypothesised that "a critical mediating factor is likely to be phonological memory or the ability to find in one's articulatory repertoire the best segmental sequence to correctly reproduce a whole adult target, which requires flexible and well-practiced articulatory skills, good planning capacity and the ability to integrate perceptual experience with these skills" (Vihman et al., 2013, p.66) to explain their finding of a strong correlation between persistent reliance on templates and morphology a year later.

Parent input and interaction: The role of parental input and verbal interaction were implicated in the observed low rates of vocalization insomuch as children with low volubility fail to benefit from conversational interactions that promote vocabulary and language acquisition (Mirak & Rescorla, 1998; Paul & Jennings, 1992; Pharr et al., 2000; Rescorla & Ratner, 1996; Vihman et al., 2013). Rescorla and Ratner (1996) hypothesized that parents of the late talkers in their sample who were relatively nonverbal may have made few conversational demands on their children either to match their children's interaction styles or in response to them.

Findings from these studies also raised a mechanism of language acquisition related to parent-child interactions. The children in Rescorla and Ratner's study (1996) who were less verbal and used a more restricted inventory of sounds may have prompted their caregivers to perceive them as less capable communicators which impacted their linguistic progress. On the other hand, children who verbalized early could have parents who imitated them which contributed to their lexical knowledge. As mentioned previously, young children first acquire a repertoire of sounds that they gradually attach meanings to as they learn words during their social experiences. They employ 'elicitation operations' to elicit language input from responsive communication partners as evidenced by studies that showed caregivers respond differently to infants' speech-like vocalizations containing a consonant and a vowel than to vocalizations containing an open vowel only (Hoff & Parra, 2011). Thus more mature vocalizations elicit more caregiver responsiveness, which in turn supports further language development.

To summarize, the evidence reported by studies that have sought to examine and compare the relationship between phonology and the lexicon of late talking toddlers to their typically developing peers has indicated that typical lexical development is accompanied by developmentally appropriate phonological systems, and delayed lexical development is accompanied by less-developed phonological systems. Late talkers had less complex and less systematic phonologies, which were manifested much earlier at infancy in their babbles. Features found in their babbles continued to be observed in their phonological systems once they began producing words, and as their vocabularies increased. Subsequently, they continued to be at a disadvantage in acquiring words accompanied by less well-developed phonologies as evidenced by the reported significantly lower scores for late talkers than their typically developing counterparts on a variety of measures of phonological performance both at the consonantal and syllabic levels and these developments accompanied lexical development accordingly. The phonological development of late talkers, however, is delayed not atypical. Taken together these studies report a similar interplay between factors (physiology, interaction with and input from caregivers, as well as practice) that contribute to speech production in late talkers as in typically developing children (Stoel-Gammon, 2011).

While a bidirectional relationship has been reported between phonology and the lexicon in typically developing toddlers, this relationship in late talkers is unclear. The question remains whether impairment in lexical acquisition restricts the development of the phonological system or if early phonological delay causes slow vocabulary growth. Mirak & Rescorla (1998) concluded that a diverse repertoire of consonants observed in their cohort of 24 and 31 months old children “affects, or is affected by, the overall amount of lexical production, with the direction of this relationship being unclear” (p. 15). Stoel-Gammon (1989) appeared to support the view that lexical development sustains phonological development based on the evidence that larger vocabularies require larger articulatory repertoires and that as children's vocabularies grow, more specified phonological representations are necessary in order to keep different lexical items distinct. Stoel-Gammon (2011) proposed that 'from birth to age 2;6, the developing phonological system affects lexical acquisition to a greater degree than lexical factors affect phonological development' (p. 27). Based on the evidence on late talkers' productive phonology up to this point, this proposal would reasonably explain their delayed lexical acquisition. Stoel-Gammon's postulation, however, has not gone uncontested (Edwards, Munson, & Beckman, 2011; Storkel, 2011). Briefly, these authors argued for reference to a wider scope of data that includes incorporation of findings on multiple representations of words (Edwards et al, 2011) as well as a framework of multiple processes in order to gain better insight into the influence of the characteristics of the ambient language on word learning (Storkel, 2011).

Therefore, in the next section, the focus of this thesis shifts from evidence for the relationship between phonology and the lexicon based on observable phonological and lexical behaviours towards examining the evidence to explain the connection between these observable behaviours with a range of underlying mechanisms. An understanding of the associations is derived from recent studies that examine the ability of late talkers in repeating non-words and studies that examine their ability to detect the statistical properties of their ambient language for word learning.

2.4.2 Nonword repetition and late talkers

While there is strong evidence of a relationship between speech production and vocabulary in late talkers, it is useful to consider underlying phonological mechanisms as well. One means for understanding the underlying mechanisms underpinning children's phonological and lexical development has come from studies on children's ability to repeat novel words using non-word repetition tasks. During a non-word repetition task, children are required to repeat target non-words of varying combinations of consonants and syllable-lengths deemed to least likely resemble real words. Most of these studies have involved typically developing and language impaired children above the age of 4-

years old (Kan & Windsor, 2010). Non-word repetition tasks have been identified as a reliable clinical marker for SLI (Chiat & Roy, 2007; Dispaldro, Leonard, & Deevy, 2013; Dollaghan & Campbell, 1998; Gathercole, 2006). Children with SLI have been reported to perform relatively poorer to typically developing age peers as well as younger typically developing children matched on language (Coady & Evans, 2008; Graf Estes, Evans, & Else-Quest, 2007; Kan & Windsor, 2010). Based on such findings in older children, it was subsequently suggested that screening younger children's performance on non-word repetition tasks may facilitate earlier identification of those who may be at risk for delayed vocabulary and later language development (Chiat & Roy, 2007, 2008; Roy & Chiat, 2004; Stokes et al., 2013; Stokes & Klee, 2009a; Vance, Stackhouse, & Wells, 2005). To date, studies relating nonword repetition skills and vocabularies of late talkers compared to typically developing peers are few. The studies within the work of Stokes and colleagues are highlighted here (Stokes, 2009a, 2009b; Stokes et al., 2013).

Stokes and Klee (2009b) examined the influence of various predictive factors on the development of vocabulary in 232 children between the ages of 24 and 30 months both with typically developing and delayed vocabularies. One of the tests used was a nonword repetition task, comprising target non-words between one to three syllables. It was found to be the only variable that made a significant unique contribution (24%) to the proportion of variance accounted for in this cohort's vocabulary scores. This test was later revised to include non-words comprising four syllables. They found that this revised version more accurately distinguished late talkers from those with typically developing language development and proposed that it had potential in identifying toddlers who may be at risk for delayed language development (Stokes & Klee, 2009a).

In a recent study, Stokes et al., (2013) used the non-word repetition task to study the relationship between children's ability to repeat non-word accurately and the number of different words they used expressively (as a measure of lexical diversity). The performances by two groups of young children, 21 late talkers and 92 typically developing children aged 2 years, were compared. They found that although the groups were similar in their overall receptive vocabulary sizes, the late talkers had significantly more words that they understood than that they used productively. Typically developing children's non-word repetition was not significantly correlated with their lexical diversity. In contrast, these variables were strongly correlated in the late talkers. In fact, number of different words as a measure of lexical diversity was found to be the sole predictor explaining about 53% of the variance in LTs' non-word repetition scores according to these authors' regression analyses.

While few, these studies demonstrate a strong association between toddlers' non-word repetition and expressive vocabulary size and that a non-word repetition task could be a useful index of concurrent expressive vocabulary skills and a predictor of concurrent language outcomes. Few studies have tracked the developmental trajectories of late talkers' non-word repetition abilities and vocabulary sizes longitudinally across development. A close reference is a study by Petruccelli, Bavin, and Lesley (2012) who investigated the memory skills in three groups of children (typically developing, resolved late talkers, and those with SLI) aged 5 years selected from a community sample. Children were tested on measures of memory including sentences recall and nonword repetition. They reported that typically developing children and resolved late talkers displayed comparable scores on all measures of memory. The latter, however, performed better than children with SLI. Their findings led them to conclude that 5-year old children with a history of late talker status whose language resolved do not have memory deficits.

2.4.2.1 Nonword repetition and underlying processes involved

The underlying processes involved in non-word repetition tasks have been the subject of much debate and different interpretations have been offered (Coady & Evans, 2008; Jones, 2016). Nonword repetition tasks have generally been used as a measure of memory capacity in relation to vocabulary size. Because these tasks require the temporary retention of a small amount of verbal information tested immediately after the stimulus is presented, accuracy in non-word repetition (or learning of new words) would depend on the quality of the phonological short-term storage according to one school of thought. Gathercole and colleagues have presented years of studies to link children's accuracy of non-word repetition difficulty to poor capacity in phonological memory or PSTM (Baddeley, 2003; Gathercole, 2006; Gathercole & Baddeley, 1990a, 1990b; Gathercole, Willis, Baddeley, & Emslie, 1994). In the studies by Stokes and Klee (2009a, 2009b) the non-word repetition task was similarly used as a measure of toddlers' phonological short-term memory.

There is also the alternative account that underlying phonological representations influence accuracy (Coady & Aslin, 2004). Bishop (2000) and Evans (2002) suggested that given the pervasive nature of the linguistic deficits in children with SLI, they have weak and imprecise phonological representations. Therefore according to this view, a relative lack of linguistic experience and an undetermined biological difference underpinned poorly developed phonological representations. Phonological awareness has been implicated in children's non-word repetition inaccuracy (Bowey, 2001; Metsala, 1999) and found to account for the association between vocabulary and non-word repetition consistent with the lexical restructuring hypotheses mentioned previously. Metsala (1999) argued that as children's vocabulary increased their representations reorganise to become more segmented to lay the foundation for increased phonological awareness which in turn facilitated successful non-word repetition. These studies provide theoretical and empirical support for the notion that children's performance on tasks of phonological awareness is connected to the accuracy and level of detail in their stored phonological representations. Thus, the general premise of these authors is that children require sufficient phonological representations to support repetition of both non-words and real words. Repetition inaccuracy is believed to be connected to weakly established representations. With gains in vocabulary knowledge, the phonological representations become more refined and specified thus consequently facilitating an increase in repetition accuracy. Therefore, a finding of poorly defined phonological representations or limited phonological processing skills in children with language impairment is probable considering their areas of weakness.

According to yet a different view, rather than a measure of PSTM or phonological representation, non-word repetition tasks help examiners to infer children's ability to rapidly access stored phonological representations from long-term memory for real-time phonological encoding. Other studies, on the other hand, have offered an alternative perspective to account for the role of phonological representations; one that relates to access to motor program. For example, Stokes (2013) posited that while the groups in her study were similar in their ability to form phonological representations, they differed in their ability to activate them for active production. That is, unlike their peers with typical language development, late talkers were less able in utilizing their knowledge of words or word parts (lexical knowledge) and rapidly recruiting the phonological segments or syllables of known words to reproduce a non-word just heard. In another study, Stokes et al., (2013) concluded that the late talkers in their study were not able to rapidly access phonological representations to produce motor programs for both existing (known words) and new (non-word) words.

There is also the account that the structure of the lexicon influence accuracy (Coady & Aslin, 2004). Nonword repetition is instead influenced by vocabulary development and improved sensitivity to phonological structures of the ambient language. This is evidenced for example, by studies that found children to be better at repeating sequences that conform to the phonology of their ambient language compared to those of an unfamiliar language (Bowey, 2001; Metsala, 1999; Thorn & Gathercole, 1999). Research on children with language difficulties found that they were unable to utilize or retrieve existing stored phonological segments or syllables to facilitate reconstruction of a non-word for repetition unlike their typically developing peers (Stokes, Wong, Fletcher, & Leonard, 2006).

Nonword repetition tasks simulate learning of words that are new or unfamiliar to children. As discussed above, word learning involves a complex developmental process with various possible influencing factors. Although not the focus of the present study, further insights into the relationship between phonology and the lexicon could be gained from studies on how late talkers' learn or acquire words. Some of these studies are highlighted next.

2.4.3 Word learning in late talkers

One of the processes involved in learning words is the initial mapping of the phonological form of a new lexical item to its meaning (fast mapping) given minimal or frequent exposures to the item in various contexts (Kan & Windsor, 2010). In a recent study, Ellis Weismer and colleagues (2013) used a fast mapping paradigm to compare its effects on children's comprehension and production of two familiar and two unfamiliar words (labels for familiar and unfamiliar referents). The children in the study were a group of late talkers and typically developing peers matched on nonverbal cognition, age, and level of mothers' education. Their results showed that typically developing children and late talkers performed similarly only on the tasks of comprehension involving familiar words. Typically developing children, however, performed significantly better on all other tasks (comprehension of unfamiliar words, and production of both familiar and familiar words). Their results showed that fast mapping deficits affecting late talkers' comprehension of novel words at age 24 months, impacted word learning at age 30 months which in turn further affected language comprehension at age 66 months. Although various limitations of the study have been raised (Ellis Weismer et al., 2013), it provides some preliminary insights into possible differences in the cognitive processes employed between toddlers with typical and delayed language development.

Word learning is also influenced by the lexical and sublexical factors (characteristics of the phonology and lexicon) of the ambient language. There are phonotactic constraints on the way in which phonemes (sound patterns) can be arranged to form syllable patterns (word boundaries, CV combinations) in the English language (phonotactic probability). Similarly, an English word can be given neighbourhood density values depending on how many words comprise sounds sequences that frequently occur in the language. Phonotactic probability (PP) and neighbourhood density (ND) are strongly correlated (Storkel, 2004; Vitevitch, Luce, Pisoni, & Auer, 1999).

According to statistical learning theory language learners are sensitive to the statistical (probabilistic) properties or regularities of the phonological and lexical characteristics of words in their ambient language and utilise their knowledge of sequential patterns to facilitate word learning (Saffran & Wilson, 2003; Stokes, 2014; Stokes et al., 2013; Stokes, Kern, & Dos Santos, 2012; Storkel, 2004, 2009). Therefore, acquisition of expressive language also hinges on children's ability to detect, compare, and manipulate words of their ambient language at an intra-syllabic level and sub-lexical levels. Children as young as 21-23 months are able to deploy the statistical strategy of using the lexical category of words to map other newly acquired words into the same category (Lany & Saffran, 2010]. Studies examining lexical and sublexical factors that affect word learning in late talking toddlers using different methods are highlighted next.

MacRoy-Higgins and colleagues (2013) examined and compared the effects of PP and ND on typically developing children and late talkers' lexical acquisition as measured on tasks of comprehension (picture naming), speech sound accuracy, and phonological representations (detection of mispronunciations in novel words). These children were matched for age, gender, socioeconomic status, and cognitive abilities. The authors found that unlike their typically developing peers, the late talkers demonstrated a different use of phonological cues. Specifically, children who were typically developing showed stronger sensitivity for words containing high PP/ND all tasks. On the other hand, the late talkers did not demonstrate a difference in for words with either characteristic for all tasks. The authors concluded that late talkers' poor sensitivity to the regularities in the phonological system and restricted inventory of sounds possibly inhibited their ability to store the phonological forms needed to learn words. Nonetheless, analyses of individual differences revealed variability in this group's level of sensitivity.

Stokes (2010) aimed to address this variability in order to distinguish between late talkers who will resolve and those whose impairment will persist. She examined the statistical properties of 222 toddlers' productive vocabularies to relate vocabulary size to the level of frequency that a word is used in the language (WF) and neighbourhood density of participants' expressive lexicons. She found that children with relatively large vocabularies used high-frequency words and words with few phonological neighbours (sparse ND). In contrast, late talkers used low-frequency words and those with high neighbourhood density (although variability in WF and ND in this group were also noted).

Subsequent studies on French- and Danish-speaking children similarly found more than 40% of the variance in toddlers' expressive vocabulary sizes were accounted for by phonological neighbourhood density (Stokes, 2010; Stokes, Bleses, Basboll, & Lambertsen, 2012; Stokes, Kern, et al., 2012). This led to a proposed theory of an extended period of using high ND by late talkers as a statistical learning strategy to facilitate word learning which they attributed to a deficit in PSTM (Stokes, Kern, et al., 2012). However, in a more recent study using the vocabulary scores of 325 children, Stokes (2014) found that late talkers' vocabularies were different from their typically developing peers' in terms of mean NDs for their expressive vocabularies relative to receptive vocabularies. Specifically, only the expressive vocabularies of late talkers contained higher mean ND values than receptive vocabularies. In addition, the ND of late talkers' vocabularies was comparable to that of younger language-matched 18 months old typically developing infants. Results from this study led Stokes (2014) to conclude that late talkers' small expressive vocabularies were not due to their inefficiency in how they extract the statistical properties of their ambient language as a mechanism for lexical acquisition but in the level of detail between their phonological representations required for word production.

2.4.4 Summary

In summary, this chapter started with a brief overview of the general patterns of young children's phonological and lexical development to set the context for the subsequent discussion on late talkers. This was followed by an overview of selected studies comparing the phonetic and phonological characteristics of late talkers to those of typically developing young children. Findings reported by these studies were synthesised drawing attention to the main theoretical concepts or hypotheses raised by the different investigators to explain the interplay between phonology, lexical size and the various mechanisms of language acquisition proposed. To further elucidate understanding of the relationship between phonology and the lexicon as well as factors that influence acquisition, studies involving LTs that examined the underlying processes implicated in their accuracy on non-word repetition tasks from the perspectives of phonological memory and sensitivity were cited. This was followed by studies examining lexical and sublexical factors that impact late talkers' word learning. These studies suggest that measures of children's phonological abilities could contribute to a better understanding and early identification of toddlers with speech and language delay.

Against this background this thesis now focuses on a model or framework that could be used to efficiently gather data to inform about how to examine and map interactions between auditory input, underlying cognitive-linguistic processes and their speech production output, as well as to elucidate understanding of how the growth of phonological competence maps onto growth in children's emerging literacy skills (Stackhouse, Pascoe, & Gardner, 2006).

CHAPTER 3 THE PSYCHOLINGUISTIC FRAMEWORK

Child language experts largely agree that the observable behaviours of phonology and language follow predictable sequences or courses that are influenced by multiple factors. However, the precise nature that underlies the process of speech and language acquisition continues to be ardently debated. Research across different disciplines (e.g., psychology, acoustics, linguistics, psycholinguistics, medical) spanning decades have presented various theories and models for the process of how speech input is translated into linguistic codes (phonological processing). These theories are also often contradictory; rendering the task of synthesising various theoretical perspectives very challenging and it is beyond the scope of this thesis to detail each account. Much of the disagreement centres on the concepts of segmentation, storage of speech units, nature of the representations of syllables and phonemes, and how the actual speech processing mechanism operates (Bernhardt & Stoel-Gammon, 1994; Hayes, 2011).

Since the 70s, a number of phonological theories and models such as Government Phonology (concepts of phonological rules), Optimality Theory (constraints) or Natural Phonology (preferences) have grown out of generative phonology to describe how language structure links to speech output. In general, according to the linguistic perspective to traditional phonology, listeners perform a certain kind of processing or categorisation on the speech input they perceive. That is, the incoming speech stream is segmented and categorised into segments (syllables, phonemes) as the basis for all the further analyses, by identifying distinctive features or via rules of abstraction (e.g., knowledge of neighbouring structure or morphological boundaries or grammatical rules). The focus of linguistic theories is on the structure of the language and how this structure relates to speech output.

Within linguistic theories is the concept of nonlinear phonology which attempts to account for the relationships between phonological units as hierarchical in nature and that the production of speech involves many elements that function independently as well as in relation to one another (Bernhardt & Stoel-Gammon, 1994). Nonlinear phonological theories, as with earlier theory of generative phonology advocated by Chomsky and Halle (1968), present two levels of representations of speech sound namely the surface and abstract underlying representations. Abstract underlying representations are perceived to be the basic forms of speech sounds prior to undergoing developmental changes or processes in order to generate the surface representations or the actual production of speech (Hayes, 2011; Krämer, 2012). Generative phonology proposed that the grammar of the phonology transforms the underlying representation into a surface phonetic representation. Nonlinear theories however place emphasis on hierarchical and multitier representation rather than on rules or processes.

While linguistic approaches offer much description of speech output, they, do not explain the potential underlying psychological processes or mental operations involved which psycholinguistic approaches aim to address (Baker, Croot, McLeod, & Paul, 2001). Linguistic theories provided the foundations for the concepts of phonological representations and phonological processing.

Unlike linguistic frameworks the focus of psycholinguistic theories is on words as the basic units of speech, and on the recognition of sequences (facilitated by phonetic and phonotactic cues, as well as statistical information about frequency of speech combination in particular positions) in speech input, rather than the segmenting of speech into and categorising its parts. Psycholinguistic research suggests that listeners recognise and process both speech segments and words in the stream of speech simultaneously including the involvement of a feedback loop. A shared methodological approach between psycholinguistic frameworks is that it is possible to distinguish between processing components to identify involvement or deficits, primarily by comparing dissociations between tasks which allows for a more targeted and integrated intervention to be developed. Accordingly, various psycholinguistic models have been proposed which attempt to account for the specific levels of cognitive processes beginning with the perception, storage, and retrieval of words or production of speech (Baker et al., 2001). The mental lexicon thus comprises underlying representations that store the information needed to recognize (extract and store phonetic information from auditory input and link it to meaning), and generate words (from stored articulatory instructions). There is much debate regarding the status and form (even the existence) of underlying representations (Dinnsen, O'Connor, & Gierut, 2001). Nonetheless, it remains a useful tool to parsimoniously describe the phenomenon of phonological development and for the purpose of comparing underlying systems in the current study. The psycholinguistic framework of Stackhouse and Wells (1997, 2001) is a more recent model that will be discussed next.

This model has been widely applied in cross sectional research investigating children's speech, lexical, and literacy difficulties, as well as in intervention (Constable, Stackhouse, & Wells, 1997; Nathan, Stackhouse, & Goulandris, 1998; Pascoe, Randall-Pieterse, & Geiger, 2013; Pascoe, Stackhouse, & Wells, 2005; Vance et al., 2005; Waters, Hawkes, & Burnett, 1998). It has also been used longitudinally for example to track a range of speech processing tasks in children with Speech Sound Disorders (SSD) aged 4, 5 and 6 years and typically developing peers Stackhouse et al. (2002) and early literacy skills in different groups of children with varying speech and language skills (Nathan, Stackhouse, Goulandris, & Snowling, 2004). Although the speech processing model of this framework was not originally developed for the specific purpose of identifying subgroups, it can be used to gain insight into the nature of children's problem and to determine common profiles to differentiate between groups (Stackhouse, Bishop, & Leonard, 2000; Vance et al., 2005).

As with all models, this one is not without its own limitations. First, it only investigates single word speech processing. Second, the phenomenon of co-articulation highlights the difficulty with a notion of single one-to-one mapping of linguistic unit or phoneme-specific phonological representations to speech unit (A. Smith, 2006). Nonetheless, it remains a useful framework for identifying the level at which speech processing is disrupted in an impaired phonological system to be addressed in therapy, as has been demonstrated in various case studies and profiling of the underlying speech processing abilities of individual children both with and without speech difficulties (Stackhouse, Pascoe, & Gardner, 2006; Stackhouse & Snowling, 1992; Stackhouse, Vance, Pascoe, & Wells, 2007; Stackhouse & Wells, 1997). It can also offer clinicians a systematic, theoretically grounded approach to intervention (Baker et al., 2001; Stackhouse & Wells, 2001).

3.1 The psycholinguistic framework of Stackhouse and Wells

The Stackhouse and Wells psycholinguistic framework is grounded on psycholinguistic and cognitive neuropsychological research (Stackhouse & Wells, 1997, 2001). The framework is based on a linear model that includes a single lexicon containing an underlying representation called lexical representations connected to related input and output processes beginning with auditory perception through to motoric execution that are perceived to underpin speech production throughout the various phases of development. Technically, children's speech productions are described in phonetic and linguistic terms followed by an investigation of underlying psycholinguistic processing. A foundational concept of the framework is that an intact speech processing system comprising input, storage and output skills, underlie children's speech and literacy development; such that problems with speech and literacy can be traced back to deficits in any of these three aspects of the system.

The psycholinguistic framework of Stackhouse and Wells (1997, 2001) thus allows for the development of hypotheses regarding the underlying nature (cognitive processes as sources of a particular behaviour) of children's speech, language and/ or literacy difficulties, provide a coherent model for systematically testing these hypotheses and allow for comparison of predicted outcomes with actual performance. These can be achieved through the application of three components of the framework. The first of these is a speech processing model which provides a framework for understanding the steps in speech processing. The second is a speech processing profile which outlines questions that need to be asked and methods for providing the answers in the assessment of an individual's speech processing skills. The third is a developmental phase model which provides a framework for describing a child's developmental progress.

3.2 The speech processing model

As mentioned in Chapter 2, children need sufficient knowledge of the phonological system of their ambient language and intact articulatory and phonatory (speech-motor) skills in order to generate the movement of speech muscles during the production of words or closest approximations possible of the adult forms; and these two components interact (Stoel-Gammon, 2011). In this model, speech processing refers to "all the skills included in understanding and producing speech, including peripheral skills such as articulatory ability and hearing" (Stackhouse & Wells, 1997, p.8). Therefore the focus of this model is the underlying cognitive-linguistic processes that occur between what a child hears (input process) and the production of speech (output process). Underpinning these abilities is a speech processing system that comprises input processing (the reception of spoken information), output processing (selection and production of speech) and lexical representations that store linguistic information about a language within the lexicon. The Stackhouse and Wells speech processing model provide a visual representation of this system as depicted in Figure 1. Some speech inputs are processed on-line as represented by the bold arrows while, others occur off-line and only when activated as represented by the shaded boxes (Stackhouse & Wells, 1997).

Based on the model, information (from all senses) about a speech input that is received by the brain is stored in lexical representations, which can be retrieved and produced in spoken form (in the case of a verbal child). Lexical representations are represented by three emboldened boxes separately referred to as phonological representation, semantic representation, and motor program. Although they are represented by separate boxes, these components are linked to each other as will be further discussed in the next sections. Although the grammatical and orthographic representations are not depicted in this figure, Stackhouse and Wells proposed that they are contained in lexical representations as well. The following sections briefly describe the components that are relevant to the present study and how these components are linked to each other.

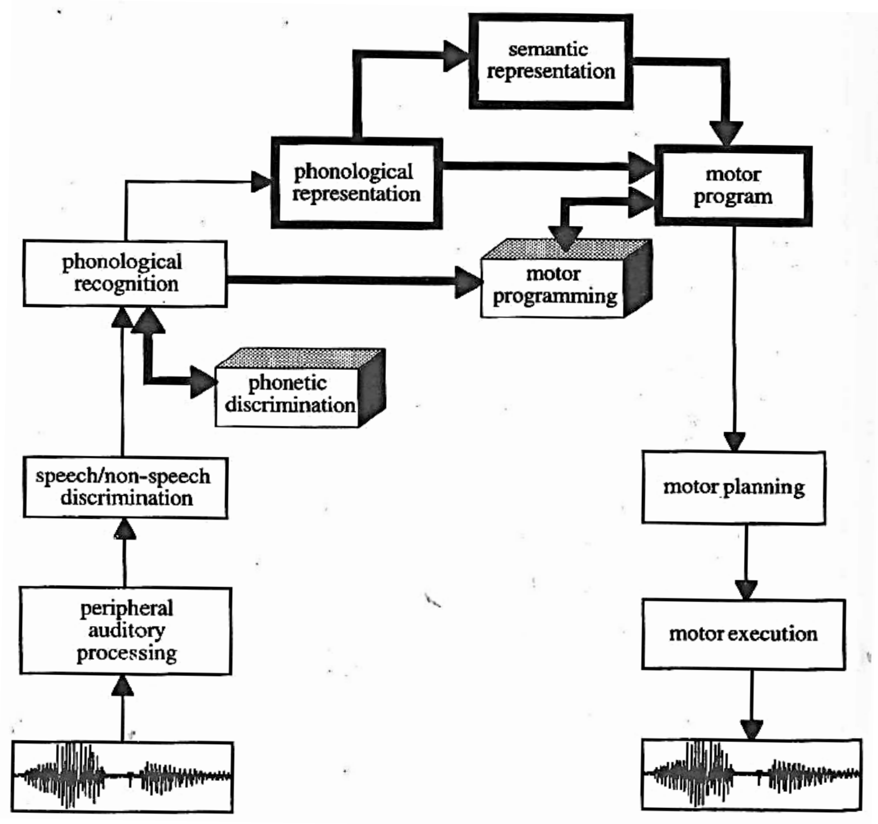

Figure 3.2. Speech processing model (Stackhouse and Wells, 1997). Used with permission.

3.2.1 The phonological recognition component

A speech signal that has been identified as distinct from non-speech noises next goes through the phonological recognition component. This is where children process and distinguish between speech input that follows the phonological patterns (probabilistic properties) of their native language (and are processed) from those that do not, and are "filtered out" (p. 149). Speech input that is deemed to contain acceptable phonological patterns is matched against an existing inventory of phonological representations. If a match is not found (a new word), a new representation is first created through a process of "segmentation and parsing of the stored percept into phonological constituents" (Stackhouse & Wells, 1997, p.169) such as syllables, onsets, rimes, codas and phonemes. The new representation is then sent to motor programming where the associated phonological units and gestural codes are assembled into a motor program.

3.2.2 The phonological representation component

Phonological representation is an abstract concept to describe stored phonological units that represent words. In the model it is hypothesized to contain "enough information for a heard word to be recognised as distinct from other similar-sounding words" (Stackhouse et al., 2007, p 18). The bold arrows indicate that phonological representation is connected to and interact with the semantic representation and motor program because a child's knowledge of words include their meanings and how they are to be pronounced. That is, incoming speech signals are matched against an existing inventory in the phonological representation and then sent accordingly to semantic representation and motor program (Stackhouse & Wells, 1997).

Theoretically, the concept of phonological representations has been closely linked to the issues of segmentation and level of detail, which will be discussed briefly here. The issue of segmentation is addressed in psycholinguistic literature as the segmentation of speech stream can occur in two contexts (Miller & Eimas, 1995). In the first context, listeners first detect the phonological boundaries or units in the speech input before processing and recognition occur. In the second context, recognition of speech input occurs facilitated by the listeners' ability to use phonological cues (phonetic, prosodic, phonotactics and transitional probabilities) to detect word boundaries before it is segmented into units. The specific mechanisms of segmentation depend on the stage of language acquisition; early language learners tend to primarily use pre-lexical and mature language learners post-lexical segmentation strategies (Miller & Eimas, 1995; Saffran, 2001).

In terms of its levels of detail, children's phonological representations can be described as being either 'holistic' or 'segmental'. According to holistic theories, prior to the acquisition of first words infants recognize words on the basis of holistic cues and early phonological representations contain only enough phonological information to enable a child to distinguish a word from words (Stackhouse & Wells, 1997; Walley, 1993). In the early stages of lexical development (small vocabularies), words are stored as single units (holistic) without phonemic details (Stackhouse & Wells, 1997; Stoel-

Gammon, 2011). It is assumed that children also store phrases as whole-speech units (Metsala & Walley, 1998; Stoel-Gammon, 2011). According to the holistic description, even when a child's spoken word may be a close match of an adult-like target word, it does not reflect an adult-like phonological representation in its underlying structure (Stackhouse & Wells, 1997; Werker, Fennell, Corcoran, & Stager, 2002). This suggests that young children may be capable of producing adult-like early words, yet not have phonological representations that contain phoneme-segments.

It was proposed that children's phonological inventories become more specified as a result of increases in vocabulary. As the sizes of the children's vocabularies grow and as more phonetic overlap occurs the phonological representations change from being holistic to being more fine-grained or segmental (Stoel-Gammon, 2011). Thus, phonological representations go through developmental changes to become more specified or distinct; containing syllable, or phonetic- and phonemic level of detail (Bowey, 2001; Metsala & Walley, 1998; Walley, 1993). These developmental changes have been attributed to hypothesized process of lexical restructuring (Bowey, 2001; Metsala & Walley, 1998; Walley, 1993). According to this hypothesis, as vocabulary expands the storage system restructures to accommodate this expansion; words that are initially stored as complete units (holistic) are now stored as specific phoneme-level details. This restructuring is said to occur with the acquisition of productive vocabulary of between 50 and 200 words and word combinations (Sosa & Stoel-Gammon, 2006; Walley, 1993). Between the ages of 17- to 23-months young children's phonological representations contain syllable features (Echols & Newport, 1992) which facilitates further segmentation into phonemic components in some words as observed by the quality of speech sound production (Sénéchal, Ouellette, & Young, 2004), as well as in their ability to reflect on sublexical components (Metsala, 1999).

Studies on the specification of infants' phonological representations however are not consistent. Recent research has presented evidence that by the age of 12 months infants can have segmental knowledge and that their phonological representation can contain specification at the phonemic levels. These studies suggest that infants begin the process of word acquisition with the knowledge of phonemes (Kuhl, 2004; Werker, Yeung, & Yoshida, 2012). That is, the process of infant word learning begin with recognising speech as phonemic units that they eventually encode into phonemic sequences with exposure to linguistic input.

Recent studies have found lexical effects in how segmentation occurs in older children; words that have more phonological neighbours (phonologically differ by one sound) are more specified than those with fewer neighbours (Storkel, 2002). Metsala (1999) studied how well children age 3-6 years were able to blend onsets and rimes of real words and form words with phonemes, using two types of stimuli: words with either few or many neighbours. She reported that children's accuracy was significantly higher for tasks that used words with many neighbours. This finding also suggests that young children might have specified representations for some words and not others. Therefore, the specification of phonological representations is not global.

In summary, what could be gleaned from all these studies is that phonological representations are important for word learning. Because of the close connection between the components of lexical representations, children's spoken words are considered manifestations of their ability to link phonological representations with other linguistic representations (Metsala & Walley, 1998; Stackhouse & Wells, 1997). For example, when learning new words children are required to process the sound-based information these words contain and establish an underlying phonological representation associated with the meaning of these words. As children's vocabulary sizes increase with increased exposure to spoken language, this facilitates the ability to make further generalizations about the phonological structure of the language which contribute to more robust underlying phonological representations that aid phonological processing. The theory of segmentation and restructuring or reorganisation imply that delayed restructuring of phonological representations leads to immature phonological processing. Since phonological processing must take place rapidly in real-time, it would also not be surprising if phonological processing in late talkers is a vulnerable system. Evidence of delayed phonological systems in children with slow vocabulary growth and the hypothesized effect of early phonological processing skills on later lexical development have led various studies to examine their relationships (Coady & Evans, 2008; Edwards, Beckman, & Munson, 2004; Stoel-Gammon, 2011).

3.2.3 The semantic representation component

Semantic knowledge relates to knowledge about associations between various elements of words. For example, knowledge that the word 'ball' refers to the concept "ball", that is the knowledge that a ball is a kind of a toy, that it is round, bounces, different from a balloon, associated with being kicked or caught and so on. As a result, various approaches to modelling semantic knowledge exist focusing on different aspects of this knowledge, and how this abstract knowledge could be conceptually represented (Griffiths, Steyvers, & Tenenbaum, 2007).

In the speech processing model, semantic representation contains stored information about the meaning of words in relation to their attributes, categories etc. As previously mentioned, when learning new words children establish an underlying phonological representation associated with the meaning of these words. That is, word learning involves a developmental process which includes initial mapping of phonological representation of a new lexical item to its meaning (fast mapping) and subsequent learning through exposure to the item in context. For example, when children learn a word from the ambient language (e.g. book) they map the phonological representation (/b/, /ɔː/, /l/) to semantic representations for the object (e.g., round, smooth, toy), as well as the motor program for the word - [bɔːl]. When they are required to name the item when shown, they access the semantic representations for the object (e.g., round, smooth, toy), and its phonological representation (/b/-/ɔː/-/l/), which then triggers the stored motor program for how the word will be articulated [bɔːl]. Young children develop "lexical categories," which they map to subsequent newly learned words that belong in the same category (Lany & Saffran, 2010). After they have learned adequate countable nouns they map words based on shape bias (Kan & Windsor, 2010). Therefore, it would be reasonable to expect children's ability to retrieve words to differ for tasks that require non-verbal recognition from those that require naming because the latter would require rich representations for retrieval and encoding of the lexical label Mc (McGregor, Friedman, Reilly, & Newman, 2002; McGregor, Newman, Reilly, & Capone, 2002).

During picture naming tasks, some children may make different types of errors (Capone & McGregor, 2005) one of which can be phonological. McGregor and colleagues (2002) studied 3- to 5-year old children's picture naming skills and how phonological and semantic representation interact to affect young children's naming of pictures. They found that naming accuracy depended by the degree of semantic knowledge that a child had about a word, and that the majority of errors made were semantic rather than phonologic approximations of the word form. They found that children often made errors related to the word's functional or physical properties (e.g. naming a saddle as chair). The authors proposed the following as explanations for these errors; (1) the children did not know the target word and did not have a label for it, (2) they do not have a current label for an item and attempted to fill the gap with a word they know, (3) they are not able to retrieve the word temporarily.

3.2.4 The motor program and motor programming components

As mentioned above, speech production involves an interaction between phonological and semantic representations connected to a motor program. The motor program stores the gestural targets or detailed instructions for how a word is articulated that has a match stored in the phonological representation. Therefore based on this model the accuracy of children's speech production is first connected to the level of detail in phonological representations stored in motor program.

When learning a new word, the creation of motor programs is facilitated by the motor programming mechanism within this model. When children learn a word for the first time, they do not have pre-existing phonological representations to rely on. Motor programming is accessed where stored phonological units are selected, assembled and this new construction stored into motor program. When production of this word is required, the stored motor program for the word is retrieved and assembled into motor planning that incorporates all the necessary gestural targets before triggering the articulators for motor execution. Motor programming is regarded as involving single words, whereas motor planning involves producing words into connected speech (Pascoe et al., 2005). Therefore using this model, specific breakdowns at different levels of input and output speech processing that underlie difficulties could be examined and identified by comparing the different tasks used. Tasks requiring children to repeat new or non-words isolate motor programming skills when compared with tasks requiring them to name (motor program) and repeat real or known words (phonological representations and motor program).

It is important to note that the conceptualization of "motor program", "motor programming" and "motor planning" based on more recent extant literature on speech motor control and motor learning differs from that of Stackhouse and Well's (1997). For example, others such as van der Merwe (2009) suggest that the articulators that will be used for the production of particular sequences of speech sounds are stipulated at the level of motor planning. Subsequently, motor plans are converted into motor programs which specify the muscles as well as when and how they are to be used during different speaking contexts or conditions (e.g., co-articulatory conditions, speed of speech) before the motor programs are finally executed. Hence, in contrast to Stackhouse and Wells' (1997) suggestion, motor planning occurs prior to motor programming and motor execution according to these authors' theoretical frameworks.

The earlier sections of this chapter presented the speech processing model as a framework to consolidate information regarding the underlying mechanisms for speech processing and production. In the section that follows, the focus shifts to how data could be gathered about the interactions between these underlying processes using the psycholinguistic framework of assessment of Stackhouse and Wells (1997, 2001).

3.3 The speech processing profile

Determining the involvement of lexical representations can only be inferred from measurable behaviours using tasks aimed at eliciting children's best attempts at recognizing and / or producing words (Stackhouse & Wells, 1997). Different researchers have used an array of tasks to assess the integrity of underlying representations. This is perhaps due to the challenging task of identifying specific level of processing tapped or taxed by task demands, and teasing apart the confounding factors involved (Claessen, 2013; Stackhouse et al., 2007). A psycholinguistic approach to assessment does not involve test materials that have been specially designed because it is "carried in the head of the user and not in a case of tests" (Stackhouse & Wells, 1997, p.49). Stackhouse and colleagues (1997; 2007) emphasized the importance of careful selection of tasks and to fully appraise the nature and demands of the tasks used so that accurate inferences can be made. To achieve this, a speech processing profile was developed based on the speech processing model to facilitate gathering and organizing assessment data of children's processing strengths and weaknesses. The speech processing profile outlines questions that need to be asked and methods for providing the answers in the assessment of an individual's speech processing skills. The series of questions probe the levels of possible breakdown in processing tapped by different tasks (Stackhouse et al., 2007).

Stackhouse and Wells (1997) use the term speech processing to "refer to all the skills included in understanding and producing speech, including peripheral skills such as articulatory ability and hearing" (p.8). However, phonological processing is also involved in the dynamic processing of information online. Hence, it is discussed briefly here in order to set the context for the speech profiling tasks used and to relate to the surface level productions found in the participants.

3.3.1 Phonological processing

Phonological processing refers to the "cognitive skills underlying the processing and production of speech" (Stackhouse & Wells, 1997, p.8). It is the mechanism by which speech input is matched to stored representations. That is, when learning new words children establish an underlying phonological representation associated with the meaning of these words by processing the sound-based information these words contain.

Phonological processing involves the components of phonological awareness and phonological memory (Bowey, 2001; Coady & Evans, 2008; Metsala, 1999; Torgesen, Wagner, & Rashotte, 1994).

According to Stackhouse and Wells (1997), phonological awareness is the "ability to reflect on and manipulate the structure of an utterance as distinct from its meaning" (p.188). It relates to the knowledge that the words in one's ambient language comprise distinct sounds with similarities and differences, and the ability to manipulate the internal phonological structure of words (syllables, onsets, rimes and phonemes). As previously discussed, phonological representations conceptually comprise enough acoustic information including the phonemic- and phonetic-level details of words to enable differentiation and discrimination between words. Various researchers have also posited that young children's phonological awareness go through similar segmentation and lexical restructuring processes (Carroll, Snowling, Stevenson, & Hulme, 2003; Swan & Goswami, 1997; Walley, Metsala, & Garlock, 2003). Phonological awareness tasks can provide additional insight into the level of detail in children's phonological representations throughout development (Claessen, Heath, Fletcher, Hogben, & Leitão, 2009; Coady & Evans, 2008; Sutherland & Gillon, 2007). Until children's underlying phonological representations for words contain segmental details, phonological awareness tasks such as onsets and rimes, that require knowledge and manipulation of syllable units and individual phonemes, will be challenging for them. This was observed in children whose phonological awareness increased as their vocabularies increased (Metsala, 1999; Metsala & Walley, 1998; Walley et al., 2003).

Stackhouse and Wells (1997) contended that phonological awareness depends on one or more components of and develops concurrently with the development of the speech processing system. Children's awareness of the units of speech input have been assessed using tasks that require them to identify, segment and manipulate these units. Another important aspect of phonological awareness is implicit knowledge of the constraints of the phonological system. This knowledge is usually assessed using tasks that require children to demonstrate their understanding of the rules that govern how phonemes can be legally combined in their ambient language (tasks of phonological legality). Nonetheless, tasks of phonological awareness may not involve the same aspects of speech processing skills. In a task which involves selecting from a choice of familiar pictures the one that rhymes with a target stimulus, children are required to detect the differences in onsets and final sounds without needing to know the meaning of the words to be successful at the task. Contrast this with a task that involves children saying a real word that rhymes with a stimulus target. Here children are required to access their stored lexicon for the accurate representation and activate motor program to generate the verbal response. Hence while both are rhyme tasks, they tap different underlying processes. Therefore accurate inference of the levels of involvement of underlying representations requires careful consideration of what behaviour a measure measures.

If we consider that new phonological input must be stored long enough for the representation of the input to be formed, a component of phonological storage would be implicated for the accuracy or complete formation of this representation. Such processing occurs in the phonological loop, which supports the functioning of the PSTM within the working memory system and temporary storage of phonological input or information while other cognitive tasks such as accessing phonological and semantic representations take place in the lexicon (Baddeley, 2003; Montgomery, Magimairaj, & Finney, 2010). Developmental constraints in PSTM would limit children's ability to process all of the phonological details in words that they hear which in turn would yield poorly defined or inaccurate underlying phonological representations in the lexicon in general. Phonological representational deficits could in turn limit children's ability to effectively retrieve words from the lexicon because there would not be enough detail to differentiate similar words by form.

Researchers disagree with regards to the direction of influence between language and memory. Some studies have found that preschool and school-aged children whose early language impairment resolved have persisting poor PSTM (as measured by non-word repetition tasks) compared to children with typically developing language (Bishop &

Donlan, 1996; Thal, Miller, Carlson, & Vega, 2005). Petruccelli et al. (2012), however, did not report similar findings in their 5-year old participants despite delayed early vocabulary development. The relationship between working memory and language is most likely bidirectional (Gupta & Tisdale, 2009), with the strength of influence changing over time. The role of PSTM is not directly determined by the speech processing model as it is considered to be subsumed within a range of tasks across different levels of processing (Vance et al., 2005). Both constructs of phonological awareness and PSTM can be measured in ways that we interpret to reflect on the robustness of phonological representations as well as the integrity of children's motor programming and motor programs.

Section 6.2.7 discusses how the measures in the current study relate to the speech processing profile, while Table 6.2 summarizes the tasks used in the current study to answer the questions of the speech processing profile. The final component of the Stackhouse and Wells (1997) psycholinguistic framework is discussed next.

3.4 The developmental phase model

Stackhouse and Wells' developmental phase model accounts for the developmental phases of children's speech and changes that occur over time. This model ties together the various concepts that have been discussed in this thesis thus far, connecting speech, language to literacy. Typically developing children go through these five phases indicating that an intact speech processing system is the foundation for the development of children's speech, language, and literacy skills (Stackhouse & Wells, 1997). Stackhouse and colleagues (2006) acknowledged that these phases do not follow a rigid structure and will overlap. The principles behind the framework, nevertheless, could provide a coherent means for understanding the stages of children's speech, language and literacy skills development.

The model comprises five phases beginning with the pre-lexical phase. This phase refers to the period of babbling and up to about one year of age when foundations for articulation and refinement of oro-motor skills in vocalization, babble, and feeding takes place. The second phase is the whole word phase which refers to a period up to about two years of age when phonological representations and motor program for children's first words are learnt as gestalts or unsegmented wholes (however as mentioned previously, recent studies present evidence for the presence of segmentation even at infancy). Words are recognized by the most acoustically salient features of the adult form. Children attempt to reproduce salient features of words stored in their motor program within the constraints of an immature output processing faculty. This phase is followed by systematic simplification between two-and-a-half and four years of age. According to this model, during this phase simplification processes emerge between the child's production and the target output structure paving the way for gradual segmentation into a sequence of phoneme-sized units. According to (Stackhouse et al., 2006), children need to be at this phase of development to begin to have a meaningful awareness of speech patterns. The assembly phase at about three to four years of age follows next wherein children master connected speech, including later developing consonants, complex consonant sequences, and intonation. Finally, the metaphonological phase takes place by about five years of age in which children begin to acquire phonological awareness.

Phonological awareness is thought to exist on a continuum with a wide variation in the levels of phonological awareness among preschoolers have been reported (Carroll et al., 2003; Lonigan, Burgess, & Anthony, 2000). Children commonly show an explicit awareness of syllables and onset/rimes as well as phonological legality by around 42 months of age. Typically developing children demonstrate awareness of rhymes before awareness of phonemes. Phonemic awareness develops later and it is not until age 5 that more consistent success on phoneme-level tasks has been observed, although most studies predominantly involved children from the middle rather than low SES (Dodd, Crosbie, McIntosh, Teitzel, & Ozanne, 2000; Hesketh, 2007; Lonigan, Burgess, Anthony, & Barker, 1998). Phonological awareness skills that are expected by five years old include awareness of phonemes, syllables, rhymes, blending, omitting, and manipulating sounds in words.

3.4.1 Connecting phonology, lexicon and pre-literacy

In pre-schoolers with typical language development, phonological awareness has been identified as one of the strongest predictors of reading ability in the first few years of schooling (Carroll et al., 2003; McCardle, Scarborough, & Catts, 2001). In 4 to 6 year old children, various researchers have found a strong correlational relationship between phonological awareness with either the size of receptive vocabulary (Metsala, 1999), or both receptive and expressive vocabulary (Cooper, Roth, Speece, & Schatschneider, 2002). In fact, Cooper and colleagues (2002) found that compared to demographic factors, both expressive and receptive language skills were better predictors of later reading skills due to their influence on the development of phonological awareness. Based on a review of a substantial body of literature the National Early Literacy Panel (2008) found strong support for the relationship between phonological awareness and early decoding and spelling skills, and phonological awareness was consistently found to be a predictive factor of early literacy acquisition independent of other relevant variables such as SES and IQ.

Previous studies on the impact of pre-schoolers' speech difficulties (regardless of their levels of severity) have reported that these children were at risk for later literacy development (Anthony et al., 2011; Gernand & Moran, 2007; Holm, Farrier, & Dodd, 2008; Larrivee & Catts, 1999; Rvachew, 2007). In a longitudinal study of children with primary speech difficulties it was found that children with pervasive speech processing difficulties at age 3 or 4 years were predominantly at risk for speech and literacy problems that persist into the school years (Nathan et al., 2004). Speech difficulties that persist beyond the metaphonological phase of development (age five) will continue to affect the development of phonological awareness due to the lack of stability in children's patterns of speech output which is needed for discrimination and manipulation (Stackhouse et al., 2006). Children with speech difficulties vary in their phonological awareness skills (Rvachew, 2007). As phonological awareness encompasses a wide range of constructs, what remains unclear is the connection between specific aspect/s of phonological awareness to later development of literacy skills in this population. Studies involving pre-schoolers without speech difficulties have reported that children at risk for literacy difficulties have poor awareness at the level of phonemes (Anthony et al., 2011; Dodd et al., 2000; Hesketh, 2007).

The relationships between phonology, the lexicon and literacy have important theoretical significance. Yet, while many longitudinal studies have attempted to relate late talkers' future language skills from early vocabulary, few studies have examined late talkers' emerging literacy skills such as phonological awareness. Preschool and school-age children with language impairments have been reported to perform poorly on phonological awareness tasks, such as rhyme and alliteration production, compared to their age-match and language-match peers (Fazio, 1997; Leitao, Hogben, & Fletcher, 1997). Language impaired children with co-occurring speech sound disorders are similarly found to have inferior phonological awareness compared to typically developing peers and at a higher risk for later reading difficulties (Peterson, Pennington, Shriberg, & Boada, 2009; Preston, Hull, & Edwards, 2013; Sices, Taylor, Freebairn, Hansen, & Lewis, 2007). At school age, although children with persistent expressive language delay achieved scores that were well within the normal range, they differed on measures of phonological awareness compared to typically developing peers and late talkers whose language difficulties had resolved at follow-up (Gillon, 2002; Paul, Murray, Clancey, & Andrews, 1997). Older children with a history of late talker status continue to achieve significantly poorer reading scores compared to typically developing peers matched on nonverbal cognitive ability, SES, and age at intake (Rescorla, 2002). Snowling and Stackhouse (2006) described the different profiles of children who were identified as at risk for later reading problems tested on an array of measures including language skills, phonological awareness and letter knowledge. Oral language ability was found to distinguish between those who went on to develop expected reading skills at age 8 from those who had difficulties. The authors concluded that children who developed expected reading skills were able to rely on their language skills to compensate for their deficit in phonic decoding.

Pennington and Bishop (2009) reported a cognitive overlap between speech, language and reading impairments as a function of comorbidity in older children with a prominent role played by phonological representations and processing deficits. Nonetheless, they also reported that multiple deficits should be considered in attempting to understand persistent language impairment rather than focusing on single underlying deficit in isolation as it is possible for children to have typical language development yet have an underlying deficit e.g. in PSTM. As with older children, it is also of theoretical and clinical importance to understand the role of phonological deficits and their overlap in young children with and without a history of late language emergence. An improved understanding of the development and relative contribution of phonology in relation to language ability will form a firmer basis for explaining the development and acquisition of young children's phonological awareness and later literacy skills.

To summarize, delayed phonological systems in children with slow vocabulary growth and the effects of early phonological processing skills on later development in speech, language and literacy skills form a basis for examining the relationships between phonology, early phonological processing and lexicon in very young children with typical and slow language development. To further elucidate the relationships and interactions, and the hypotheses raised, the current study draws on the psycholinguistic framework of Stackhouse and Wells as an approach to examining and describing children's performance, as well as for the interpretation of performance throughout the developmental phases (Stackhouse et al., 2006; Stackhouse & Wells, 1997; Stackhouse et al., 2002). Against this background, the next chapter aims to present the current research, its main aims and hypotheses.

CHAPTER 4 THE PRESENT RESEARCH

A key motivation behind the current study is to extend previous findings by examining both surface and underlying phonological systems and lexical development together in a prospective longitudinal study as observed in a cohort of toddlers with typically and late developing language over 18 months intervals when the children were aged 2;0, 3;6 and 5;0. The main aims of this study were to:

1) increase understanding of growth trajectories (patterns of commensuration or dissociations within and between groups) in language and different components of the phonological systems,
2) relate outcomes to observed patterns within and between groups, and
3) explore the underlying mechanisms affecting development via a psycholinguistic model.

4.1 Research rationale

Over the last three decades research has sought to improve methods of identification (Klee et al., 1998), descriptions of characteristics, outcomes and underlying causes for late talking, as well as knowledge of risk and predictive factors for both short- and long- term outcomes (Rescorla, 2011). While findings are currently varied, environmental and genetic factors and the interactions between them have been found to be strong predictive factors affecting young children's language development (Reilly et al., 2010; Rescorla, 2011) but prediction accuracy is still tenuous. Given the persistent delay in phonological development in a portion of late talkers (Paul & Jennings, 1992; Roberts et al., 1998), the addition of phonological measures may better predict whether a late talker will later resemble a child with typical language development or a child with persistent language impairment.

As addressed in Chapter two, few studies to date have examined the longitudinal relationship between phonology and the lexicon, as well as the role of phonology in accounting for the slower acquisition and learning of words in young children identified as late talkers. Nonetheless, based on existing late talker research, phonological and lexical developments are most notably interdependent during the point in development when first words emerge. The nature of the relationship and developmental trajectories beyond this point up to school entry, however, has not been thoroughly explored and remains unclear. Further research is needed to track the influence of phonology beyond the initial phases of emerging language, as well as to separate the similarities and differences in the phonology-lexicon relationships and developmental trajectories between typically developing children and late talkers.

Better understanding of the relationships has important theoretical, clinical and research implications. Because language development is a foundational factor underpinning later educational, academic, social, emotional and behavioural development, close examination of early relationship between phonology and the lexicon could lead us to specific intervention strategies that could limit, if not prevent, the detrimental impact of early weaknesses in language development. For example, findings could guide specific clinical decision-making such as whether language or phonology should be prioritised for intervention and guided by assessment data. Continued investigations will also provide invaluable information for various stakeholders from the medical and educational communities, governmental bodies, especially families.

Available data show that late talking toddlers evidence weaknesses in phonology and language, with various possible underlying factors implicated. Therefore, just as equally important is the investigation of underlying processes and how the interplay between them impacts expressive phonology and expressive language outcomes. An understanding of the processing demands for speech and language is important for making accurate interpretation of children's performance. Such understanding could be achieved by gathering the trajectories manifested by typically developing children to use as reference in examining similar trajectories in late talking children. Various studies have reported a close relationship between young children's performance on non-word repetition tasks and vocabulary or language. The influence of phonology on non-word repetition abilities has also been proposed (Shriberg et al., 2009; Vance et al., 2005).

However, data to support different observations about young children's phonological and lexical acquisition and its impairment are mainly presented as either domain-specific accounts hypothesizing deficits in specific language abilities, or processing accounts hypothesizing deficits in processing capacity (Stoel-Gammon, 2011; Storkel & Morisette, 2002). This forms another basis for examining the relationships between phonology (productive and phonological processing) and the lexicon of late talking toddlers in the current study.

The relationships between phonology, the lexicon and literacy have important theoretical significance. Yet few studies have examined emerging literacy skills as a measure of outcome. A major area of attention for children with a history of slow language growth as they enter school is the link between phonology and language to phonological awareness given its link to later literacy skill which is in turn considered the gateway to knowledge and school achievement. There is encouraging evidence from longitudinal studies and meta-analyses (involving children older than 2 years) that speech impairment, expressive vocabulary, non-word repetition, and phonological awareness skills are among the best predictors of future reading skills, which is closely linked to school achievement (Bird, Bishop, & Freeman, 1995; Carroll & Snowling, 2004; Catts, Fey, Tomblin, & Zhang, 2002; Pennington & Lefly, 2001). While not the focus of the current study, it should be noted that children diagnosed with SLI and those at risk for dyslexia not only share a common history of phonological deficits but also late talker status (Bishop & Snowling, 2004; Thal et al., 2004). Therefore, an improved understanding of the development of phonology in relation to language ability will form a firmer basis for explaining the development and acquisition of emerging literacy skills.

Five is the age when the prevalence of Specific Language Impairment (SLI) is estimated to be 7.7% based on data from the United States (Tomblin et al., 1997) and 7.6% based on data from the United Kingdom (Norbury et al., 2016). Five is also the age when children in NZ have either started or are just starting school and would be receiving formal pre-literacy instruction. Therefore a major area of concern for children with a history of early slow lexical growth is if their early difficulties persist and render them to continue to be 'at risk' for significant learning difficulties when they begin formal schooling at five and throughout their years at school.

In summary, an understanding of the interface between phonological and lexical development in late talkers and a comparison of how they acquire phonology and language at different points in their developmental continuum may provide a different perspective on understanding relationships, contribute to current understanding of late talkers' characteristics and facilitate more effective methods of early identification or assessment of late talking toddlers. Knowledge of the relationships and connections between underlying components and impairments in underlying processes or mechanisms could chart the way to exploring possible causes of late talking, facilitate prediction of later outcomes and prove to be of benefit in the diagnosis and preferred remediation strategy for late talking toddlers.

4.3 Research questions and hypotheses

The present study was motivated by the search for answers to two overarching questions; (1) Does a similar relationship between late talkers' phonology and the lexicon exist as in children with typical development, and does this relationship change with development? (2) Do underlying impairments in their phonological systems contribute to early expressive language delay and persistence at outcomes? To arrive at the answers, the following sub questions and hypotheses were posed:

Research question 1: Is there a statistically significant concurrent correlation between individual measures of phonology and the lexicon at each time-point for TD children? Does a similar relationship exist at the same time-points for LTs? Given these findings, are there observable across-group differences in relationships?

Hypotheses: A relationship has been found between the two domains of language in typically developing children. Therefore it may be reasonable to hypothesise that a similar relationship could be expected between phonological and lexical development in late talking children. Research suggests strong correlations between vocabulary size and both surface and underlying phonological systems. Therefore, significant bivariate correlations would be found between expressive language and individual measures of phonology (percentage consonant correct for picture naming and non-word repetition) for both typically developing and late talker groups at least at age 2;0 where the lexicon is at the early stage of development.

Research question 2: Based on the correlational analyses of question 1, is there a significant difference between the typically developing and late talker groups on phonology and language at each time point? If significant differences can be detected, do late talkers show the same patterns of development as children with typical development with respect to the relationship between measures of phonology and language, albeit delayed?

Hypotheses: Significant differences are expected between mean scores for typically developing children and late talkers for each measure at every time point, with significantly lower scores for LTs. At age 3;6 and age 5;0, the expressive language skills of 50%-75% of children with a history of late talker status were expected to resolve and fall within the normal limits on the respective standardized language tests, even if performance fell within the low average range. Previous studies have estimated between 40% to 71% rates of resolution among their LTs (Dale et al., 2003; Paul, 1993; Rescorla, Dahlsgaard, et al., 2000).

Research question 3: Following on from the correlation analyses of question 1, what proportion of variance in expressive language is explained by each measure of phonology in typically developing children and late talkers?

Hypotheses: At age 2;0, PCC scores for both measures of picture naming and non-word repetition will contribute significantly to lexical and language development. PCC for picture naming would have a larger effect size for late talkers due to either scarce phonological representations or poor speech output processing. Since speech-phonological processing must take place rapidly in real-time, it would not be surprising if this is a vulnerable system in late talkers. Given current evidence, the effect of PCC for non-word repetition was expected to pervade and continue to have an effect on expressive language development at age 3;6 and age 5;0.

CHAPTER 5 METHODOLOGICAL CONSIDERATIONS

Distinguishing between late talkers whose language will and will not resolve and predicting their outcomes at preschool or school age is a complex task. Prior studies have examined the phonology, processing, and lexicon of two-year-olds' yield findings that differ as a function of various factors. Heterogeneity in research poses a challenge in filtering and synthesising the various findings across studies and the extent to which such differences contribute towards obscuring data. Both small- and large-scale studies of late talkers over the last three decades differ in the identification criteria (use of cut-offs), composition of samples (late talkers with expressive delay only or mixed receptive vs expressive delay), study design (cross-sectional vs longitudinal), and data sampling strategies and measures used (spontaneous speech vs single word naming).

5.1 Identification of late talkers

Parent report of late talkers' vocabulary has been shown to be reliable and valid (Fenson et al., 2007; Heilmann et al., 2005; Reese & Read, 2000). As previously noted, studies using parent report measures vary in how they have defined and characterised late talkers. For example, on the MCDI cut-offs at the 10th, 15th, 16th and 20th percentiles as well as -1 SD for expressive vocabulary have been used by various studies (Beckage, Smith, & Hills, 2011; Fenson et al., 2007; Reilly et al., 2007; Thal et al., 2004). Using the LDS parent report measure a commonly used criterion to describe LTs is vocabulary size below the 10th percentile (Fenson et al., 2007), and/or having lesser than 50 words or no word combinations by 24 months (Carson et al., 2003; Mirak & Rescorla, 1998; Rescorla, Mirak, et al., 2000). More recent studies have reported on the presence of word combinations at age two as a criterion for identifying LTs. For example, Poll and Miller (2013) reported that a lack of early word combinations predicted oral language and general learning abilities in middle childhood regardless of non-verbal cognitive ability and SES. Klee, Stokes and Moran (2015) found that children who were reported by their parents to have no two-word combinations at intake (24–30 months of age) or with CDI scores at or lower than the 10th percentile were more highly likely to have below average expressive language scores on a standardized language assessment.

The sample in the current study was divided into typically developing and late talker groups with the latter defined as children having an expressive vocabulary size at or less than 10th percentile or to have no word combinations as reported by their parents using an New Zealand (NZ) version of MCDI:WS (Reese & Read, 2000) which was further revised by Klee et al., (2015).

5.2 Sample composition

Studies also vary in terms of the receptive vocabulary status of their late talkers. Generally, they have either included late talkers with typical receptive vocabulary, late talkers with receptive language delay which was measured in conjunction with the use of communicative gestures in some studies or late talkers with a varied range of receptive vocabulary but not used as a factor related to outcome (Chiat & Roy, 2008; Dale et al., 2003; Desmarais et al., 2008; Ellis & Thal, 2008; Leonard, 2009; Olswang, Rodriguez, & Timler, 1998; Rescorla, 2011). Receptive skill status has been reported to be closely related to cognitive development and a strong predictive factor of later school-age language outcomes (Dale et al., 2003). The inclusion of children with receptive deficits may generate different outcomes than those with expressive delays only (Carson et al., 2003; Desmarais et al., 2008; Ellis & Thal, 2008; Paul & Roth, 2011; Rescorla, 2011). Therefore, close consideration of its potential confounding effects would be required.

5.3 Study design

Most studies on late talkers were cross-sectional in design. Large-group cross-sectional studies of typical acquisition provide normative data by which to compare children and identify impairment. However, longitudinal studies of smaller groups of children observed at repeated intervals would allow for the tracking and accounting of individual differences. The areas of concern over longitudinal study design include small sample size that would render the data as not representative of the general population.

Stokes, Klee, Carson and Carson (2005) recommended: “Large-scale longitudinal studies, combined with statistical analyses, would provide the best possible view of the nature of phonemic development” (p. 828). The current study used a prospective longitudinal study design to gather useful information about and facilitate efficient analysis of the relationship between phonology and the lexicon, and identification of potential predictors of outcomes. Participants’ skills were followed at 18-months intervals over a period of three time-points when children were two, three-and-a-half, and five years old.

5.4 Measures of phonological accuracy

In the current study, ‘phonology’ referred to both surface and underlying systems and was measured respectively using a picture naming (real words) and a non-word repetition task. A common method for investigating late talkers’ phonological characteristics is the use of spontaneous speech sampling typically during a parent-child interaction at free play. The recommended sample size necessary to obtain a complete picture of a child’s speech sound production ability varies between researchers (Bernhardt & Holdgrafer, 2001; Weston, Shriberg, & Miller, 1989). Some researchers argue that spontaneous speech sampling provides a more representative sample for phonological analysis compared to using a single-word test (Bernhardt & Holdgrafer, 2001; Ingram, 1994; Masterson, Bernhardt, & Hofheinz, 2005; Morrison & Shriberg, 1992), especially in very young children. Both advantages and limitations to using data obtained from single-word tests for the current study had been considered.

Firstly, the use of single-word tests befits the nature of a longitudinal study design and facilitates consistent comparison of data across tests and time-points since similar words were elicited. Secondly, it is considered a more time-efficient method of sampling a wide inventory of speech sounds in a consistent manner (Bleile, 2002; Khan, 2002; Masterson et al., 2005; Paden & Moss, 1985; Tyler & Tolbert, 2002). Very young children may be reluctant to talk and so it may be time-consuming or difficult to obtain sufficient sample for analysis and as previously discussed, young children may avoid using difficult words that contain sounds not from their inventory, rendering the variety of sounds and word shapes sampled in a spontaneous sample to be limited (Masterson et al., 2005; Paden & Moss, 1985; Wolk & Meisler, 1998). Therefore an elicitation task could ensure a representative sample of each participant's speech-sound production. Furthermore, McIntosh and Dodd (2008) in their preliminary findings reported the potential use of the Toddler Phonology Test (TPT) for assessing very young children's phonology. Although the sample size of the TPT (n = 37) is considerably smaller than the recommended sample sizes for spontaneous speech, they provide opportunities for the production of 105 consonants in syllable-initial and syllable-final positions, as well as 56 vowels and diphthongs of English. The use of single word naming tests like TPT avoids the problem of missing out on sounds a participant would use elsewhere but not attempt during the sampling session. Thirdly, since the adult target is known, it facilitates transcription and allows the transcriber to compare a participant's actual productions to adult targets, especially with participants who are highly unintelligible (Bernhardt & Holdgrafer, 2001; Hodson, Scherz, & Strattman, 2002; Paden & Moss, 1985). Finally, standardised tests provide norms for identifying impairments and quantitative test results that could be used to receive intervention services at schools (if needed) in addition to its psychometric advantage as mentioned at the start of this section (Khan, 2002).

While results were reported as preliminary, the Test of Early Non-word Repetition-Revised (TENR-R: Stokes & Klee, 2009) can be used for identifying 2-year-old children at risk of language impairment as well as for accurately differentiating 2-year-olds with and without early language delay accounting for 24% of variance in the participants' expressive vocabulary size (Stokes & Klee, 2009b). Non-word repetition in older children has mainly been linked to performance on language and literacy tasks rather than speech-sound production. The influence of speech or phonological processing deficits on non-word repetition abilities has been proposed (Stackhouse & Wells, 1997).

In scoring responses on a test of non-word repetition, the conventionally accepted definition of a correctly produced word is the accurate production of every speech-sound in the same order as the target (Dollaghan & Campbell, 1998). Researchers have adapted scoring conventions of accuracy in repetition tasks, such as taking into account reducing the impact of developmental phonological errors (Dispaldro et al., 2013). Developmental errors have either been scored as correct or not scored in order to ensure that group differences and diagnostic accuracy results will not be driven or complicated by individual differences in phonological ability. This allows researchers to accurately examine the impact of underlying factors such as phonological short-term memory on performances requiring repetitions and confidently rule out the contribution of limitation in production to differences in results (Dispaldro et al., 2013).

5.5 Use of PCC

The current study utilised relational analyses to judge a participant's realisation of target adult production and yield a Percentage of Consonants Correct (PCC) for the non-word repetition task and the picture naming task derived by Shriberg and colleagues (1997; 1982; 1986). Traditionally, the PCC has been used to estimate the percentage of consonant sounds that were produced correctly in a conversational sample. However, the PCC measure has been used to express the percentage of correct consonants on single-word articulation tests. It is calculated by dividing the number of consonants produced correctly by the number of opportunities for production of those consonants within a speech sample (Dodd et al., 2002; McIntosh & Dodd, 2008).

Although the use of a variety of indices such as syllable structure, phonetic variation and phonological pattern analysis have been reported in other studies, the current study uses the PCC for various reasons. The PCC is one of the most commonly used indexes to efficiently measure the severity of speech production errors. It has been found to be a robust and useful indicator of change and less affected by the choice of stimuli (Newbold, Stackhouse, & Wells, 2013). Shriberg and colleagues (1997; 1982; 1986) recommended the calculation of PCC as an index to quantify children's severity of production and judge the general level of their phonological performance. For the current study its use was deemed sufficient to serve as a summary of children's phonological development and for the purpose of studying its longitudinal relationship with the lexicon.

CHAPTER 6 METHODS

This chapter describes recruitment of participants and published measures or assessments that were conducted at each time-point. Conventions for the transcription and scoring of data are outlined and transcription reliability reported. This chapter ends with a discussion on statistical analysis. Ethical permission was obtained from the Human Ethics Committee at the University of Canterbury (Ref: HEC 2011/121) prior to conducting the study (Appendix A).

6.1 Participants

The participants were New Zealand children participating in a prospective longitudinal study called "Learning to Talk: a research project on children's early language development" (Klee et al., 2015; Newbury, Klee, Stokes, & Moran, 2015) which originally involved three time-points (Time 1, Time 2, Time 3) in the children's development. The study was extended to include data collected at Time 4.

The plan for the original study was to recruit and follow 100 typically developing and 100 late talkers over time (Klee et al., 2014). However, due to a series of earthquakes and aftershocks in the Canterbury region between September 2010 and February 2011, recruitment was postponed until the following year. As a result, the sample size was 84% of what was planned by the time data collection started, with more typically developing children than late talkers.

Participants were contacted and recruited through various means such as the university research database, preschool public health service, early childhood education centres, special education, general practitioners, and personal networks. Plunkett nurses from the preschool public health service assisted with distributing information packs containing the consent form, the study information sheet, MacArthur-Bates CDI, and Parent Questionnaire (Appendix B) to children who fit the age criteria. Information packs were mailed to parents who contacted the Child Language Centre regarding their interest. During sessions, parents were also requested if they could inform other parents they knew with children who were late to talk within the age range. Apart from age, participants were required to (1) not have an official diagnosis known to impact the development hearing, speech, and language; (2) be mainly exposed to English or reported by the parent to be exposed to another language less than 20% of the time; and (3) reside within 100km of Christchurch in order to ensure accessibility.

At Time 1 (age 2;0) the sample size was 168 which comprised 72 girls and 96 boys. The children were born between late-2009 and early-2011 and were between 24 to 31 months of age (M = 27.4, SD = 1.7) by the time they came for the first assessment session, with 93% of them first assessed then. In most cases children were accompanied by their parent(s) to the university's Child Language Centre for the assessment session. The education level of the parents in the sample who completed the questionnaire was categorized based on categories used by Statistics New Zealand and the distribution was compared to data on educational attainment of females in the general population who were between 15 and 44 years (child bearing age) according to the most recent national census (Table 6.1). Compared to the general population, our sample comprises a considerably lower proportion of mothers with no secondary qualification and a higher proportion with university degrees. Such bias is common in studies of children's language development (Rescorla, 2013).

Testing was carried out as close to 18-month intervals as possible, except for Time 2 which occurred 3 months after T1. Data from Time 2 which only measured vocabulary size, was not part of the current study and will neither be described below nor referred to henceforth.

The participants and their parents were invited to return 18 months later at Time 3 (age 3;6) for a second assessment at the Child Language Centre when they were within 42-50 months of age. Contact with families was maintained through sending children a birthday card on their 3rd birthday. Out of the 168 families who had participated at T1, 160 (95%) agreed to continue their participation. They were made up of 69 girls and 91 boys and ranging in age from 42 to 50 months (M = 45.5, SD = 1.9).

At Time 4 (age 5;0) parents were contacted via email and phone to inform them of an extension to the study. The participants and their parents were again invited to return for a third assessment at the Child Language Centre when the child turned or have just turned five. Interested parents were then sent an email which included soft copies of documents containing information about the study. A total of 114 families returned and continued their participation. There were 60 boys and 54 girls whose ages ranged between 59-68 months (M = 63.4, SD = 2.0).

Table 6.1

Mother's educational level in the sample compared to the population

Mothers' Educational level[b]	n	Sample (%)	Population[a] (%)
No secondary qualification	3	1.8	12.7
Some secondary education[c]	14	8.3	24.6
Secondary education certificates and diplomas[d]	47	28.0	35.5
University degrees[e]	104	61.9	27.1

a. Source: Klee et al., (2015)

b. Females between 15-44 years of age

c. Includes Level 1-2 Certificates

d. Includes Level 3-4 Certificates and Level 5-6 Diplomas

e. Includes undergraduate and postgraduate degrees and graduate and postgraduate certificates and diplomas

6.2 Measures

The current study was an extension of a study which involved a battery of tests. Only measures that were relevant to the current study are described in this section. In order to answer the research questions, children's phonological accuracy, phonological awareness and language ability were measured at age 5;0. All materials used to measure participants' skills at intake and follow-up were carefully selected based on various criteria such as evidence of diagnostic accuracy, relevance to the study, age appropriateness, the strength of psychometric properties and availability of NZ versions of the tests. If there was no NZ version of the test, one standardised to the Australian population was selected due to cultural similarities. Standardised assessments were considered acceptable for use in multivariate analyses to explore relative influences of the different domains. They have the advantage of being norm-referenced as well as being deemed appropriate for exploring heterogeneity in the abilities of the cohort.

6.2.1 Hearing screen

At all time-points, participants' hearing was screened using an otoacoustic emission test (OAE) at 2000, 2500, 3200 and 4000 hz at 50 dB in order to obtain information regarding cochlear status. OAE is routinely used in paediatric audiological assessments. It is non-invasive and provides reliable information in a relatively short time; especially useful in the assessment of very young and difficult-to-test participants.

6.2.2 Non-verbal ability

The Mullen Scales of Early Learning (MSEL: Mullen, 1995): Assessment of nonverbal ability is important for estimating a participant's overall developmental level as well as predicting outcome. The MSEL can be administered to children up to age 68 months and allows for the t-scores, percentile ranks, and age equivalents of its five subscales (Fine Motor, Gross Motor, Visual Reception, Expressive Language, and Receptive Language) to be calculated separately. At age 2;0 and age 3;6, participants' visual reception ability was evaluated using the Visual Reception subscale which included tests of abilities such as categorising, matching and recalling visual or spatial information. According to the test manual (Mullen, 1995) test-retest and inter-rater reliability, as well as internal consistency for the age range of two to four years are high. Good concurrent validity is also reported in the manual.

Raven's Coloured Progressive Matrices: At age 5;0 participants' nonverbal cognitive ability was evaluated using the Raven's Coloured Progressive Matrices (CPM: Raven, 1998). This is a test of non-verbal intelligence designed for use with children between the ages of 5 and 11 years. There are 36 stimulus items in total, in the form of geometrical symbols to express logical sequences. Test takers were required to select a missing element from a set of multiple choices in order to complete a pattern. The test is suitable for the study because it is easy to administer and not dependent on tax a participant's language, reading or writing abilities.

6.2.3 Language

The Preschool Language Scale, Fourth Edition (PLS4) (Australian Language Adapted): The PLS4 (Zimmerman, Steiner, & Pond, 2002) is an individually administered standardized assessment tool for children from birth to six years eleven months. It was selected because it was deemed a useful diagnostic and research tool for the purpose of identifying the participants' baseline global Auditory Comprehension (PLS4_AC) and Expressive Communication (PLS4_EC) skills, and for measuring changes in these skills at different time-points. It provides raw scores and standard scores for subtests as well as composite language skills. According to its authors, concurrent validity is good, while it inter-rater reliability, test-retest reliability, and internal consistency reported as high. Furthermore, they also reported it to be effective in identifying language impairments in children. This test was used at age 2;0 and age 3;6 but was consequently replaced at age 5;0.

Clinical Evaluation of Language Fundamentals: Preschool, 2nd Edition (CELFP2): This test replaced the PLS-4 used at age 2;0 and age 3;6 as children were scoring close to ceiling on that test. It is an Australian and New Zealand Standardized Edition of a norm-referenced, standardized test for young English speaking children aged 3;0 to 6;11 (CELF-P2; Wiig, Secord, & Semel, 2006). It has been reported to have positive psychometric validity (Friberg, 2010). It measures a broad range of receptive and expressive language skills and yields various composites based on performance on various subtests that measures different aspects of language. The subtests of the CELF-P2 were deemed to fit better with the language outcomes that this study aims to measure. The test developers used The Core Language score (derived from the scores of three subtests: Sentence Structure, Word Structure, and Expressive Vocabulary) in establishing the CELF–P2's diagnostic accuracy (Wiig et al., 2004). American Speech and

Language Pathologists report using the test frequently in the diagnosis of SLI (Betz, Sullivan, & Eikhoff, 2010). In Australia and New Zealand, it is commonly used to describe the severity of language impairment and scores are often required for children to be eligible for intervention services at school. This test generates the following indices which are derived from the cumulative measures of subtest scores (in parenthesis):

1. Expressive Language Index (ELI) designed to assess children's oral language expression [Word Structure (WS), Expressive Vocabulary (EV), and Recalling Sentences (RS)].
2. Receptive Language Index (RLI) designed to assess children's comprehension of language [Word Structure, Expressive Vocabulary, and Recalling Sentences].
3. Language Content Index (LCI) designed to assess children's semantic knowledge [Expressive Vocabulary, Concepts and Following Directions (CFD), Basic Concepts (BC)].
4. Language Structure Index (LSI) designed to assess children's understanding and use of syntactical structures and morphology [Sentence Structure (SS), Word Structure, Recalling Sentences].

6.2.4 Phonological accuracy

The Test of Early Non-word Repetition-Revised (TENR-R): A revised computerised version of the TENR (TENR_R; Stokes & Klee, 2009) was used at all-time-points. This test comprises 20 non-words, from one to five syllables in length and comprising CV and CVC structures (C = consonant; V = vowel). The non-words were low in word-likeness and articulatory complexity (the phonemes used were mostly within the phonetic inventories of two-year-olds). Each nonsense word was presented via recording only once and the child received positive reinforcement (meaningful to the child) after every attempt at imitating it. This test has not been normed although the diagnostic accuracy of the original version (non-computerized) of the TENR-R has been reported (Stokes & Klee, 2009b).

The Toddler Phonology Test (TPT): The TPT (McIntosh & Dodd, 2011) was used at age 2;0 to assess the phonological acquisition of children between the ages of 2;0 and 2;11. It consists of 37 target words selected to elicit a range of syllable structures, 105 consonants (including clusters) in both syllable initial and final positions and 56 vowels and diphthongs. Children produced these words either by naming the pictures spontaneously when shown or imitating the examiner's verbal model. According to its authors, it has high test-retest and inter-rater reliability. It provides norms standardised on samples from Australia (AUS) and the United Kingdom (UK) for both quantitative and qualitative measures. Only the percentage consonants correct (PCC) metrics from TPT were used as a measure in the current study. Calculation of PCC was done according to the instructions in the manual (percentage of phonemes correct in words that were attempted).

The Diagnostic Evaluation of Articulation and Phonology (DEAP): The Phonological Assessment of DEAP (Dodd, Hua, Crosbie, Holm & Ozanne, 2002) was used in place of the TPT at age 3;6 and age 5;0 firstly because it was more age appropriate as it has been designed for children aged 3;0 to 6;11. Secondly, it contains 50 target words, 29 of which are part of the TPT and hence ensured continuity and facilitate comparisons across time-points. Similar to the TPT, it has high test-retest and inter-rater reliability, as well as provides norms standardised on samples from AUS and the UK for both quantitative and qualitative measures. Similarly, only the PCC metrics from DEAP was used as a measure.

6.2.5 Phonological awareness

Preschool and Primary Inventory of Phonological Awareness (PIPA): The PIPA (Dodd et al., 2000) was added at age 5;0 in order to provide a profile of the participants' phonological awareness skills. The subtests of the PIPA also tap into children's metalinguistic awareness which is presumed to be a higher level function than phonology. Children in NZ enter school when they turn 5;0 and hence this is the time point when they would be receiving formal early literacy instruction. The test manual indicates that it has strong psychometric properties with strong internal consistency of subtests and reliability coefficient alpha scores above 0.7. This test also provides norms standardised on samples from the AUS and the UK. There are currently no NZ norms for this test. The RAs ensured that the procedures for test administration and scoring as described in the manual were closely adhered to. Raw and scaled scores for individual and combined subtest were used for data analysis. Brief descriptions of the subtests and administration procedures are discussed within the section on the speech processing profile.

6.2.6 Speech processing profile

As mentioned earlier, the psycholinguistic framework for assessment was utilised to gather and organize assessment data on the surface features of children's speech output and identify underlying phonological processing that could explain those surface features. Table 6.2 summarizes the tasks used in the current study to answer the questions set out in the speech processing profile by Stackhouse and Wells (1997).

Table 6.2

Speech processing profile and tasks used

Input processing skills		Tested by
A.	Does the child have adequate auditory perception?	Hearing screen
B.	Can the child discriminate speech sounds without reference to lexical representations?	Not tested
C.	Does the child have language-specific representations of word structures?	Not tested
D.	Can the child discriminate between real words?	PIPA_RA, PIPA_AA
E.	Are the child's phonological representations accurate?	PIPA_RA, PIPA_AA
F.	Is the child aware of the internal structure of phonological representations?	Not tested
Output processing skills		**Tested by**
G.	Can the child access accurate motor programs?	TPT, DEAP
H.	Can the child manipulate phonological units?	PIPA_PS, PIPA_SSeg, PIPA_PI
I.	Can the child articulate real words accurately?	TPT, DEAP
J.	Can the child articulate speech without reference to lexical representations?	TENR-R
K.	Does the child have adequate sound production skills?	Parent questionnaire
L.	Does the child reject his/her own erroneous forms?	Not tested

Note. *CELFP2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RS=Repeating Sentences; EV=Expressive Vocabulary; TPT=Toddler Phonology Test; DEAP=Diagnostic Test of Articulation & Phonology; TENR-R=Test of Early Non-word Repetition-Revised; PCC=Percentage of Consonants Correct; PIPA=Primary Inventory of Phonological Awareness; RA= Rhyme Awareness; AA=Alliteration Awareness; PI=Phoneme Isolation; PS=Phoneme Segment.*

6.2.6.1 Input processing skills

Not all levels of children's input processing were directly tested given the focus of the study on a productive aspect of speech production as well as the limited time available to each participant at assessment sessions. Only the levels that were directly tested are described here.

A. *"Does the child have adequate auditory perception?"* This level is concerned with a child's hearing perception. At all time-points, children's hearing was assessed using an otoacoustic emission (OAE) test to obtain information regarding cochlear status. OAE is routinely used in pediatric audiological assessments. It is non-invasive and provides reliable information in a relatively short time; especially useful in the assessment of very young and difficult-to-test children. Parents were also asked if their children had any history of ear problems or officially diagnosed with hearing difficulty that could affect speech and language development.

D. *"Can the child discriminate between real words?"* This level aims to investigate whether a child has an accurate internal representation of a word in mental storage. It involves an examiner naming a picture and the child is required to state if the examiner has said the word correctly. This question was indirectly answered by tasks used for Level E below.

E. *"Are the child's phonological representations accurate?"* This level taps a child's knowledge of phonological representations and the level of precision in children's segmental and rime level representations. This question was answered in the current study using the Rhyme Awareness (PIPA_RA) and Alliteration Awareness (PIPA_AA) subtests of the Preschool and Primary Inventory of Phonological Awareness (PIPA, Dodd, Crosbie, McIntosh, Teitzel, & Ozanne, 2000). These subtests require children to compare the similarity of onsets and segment words at an intra-syllabic level. The PIPA_RA assesses children's ability to judge if words contain phonological similarity and requires them to demonstrate that they understood that words that rhyme shared endings that sound similar. The examiner named every picture in a choice of four and children were asked to identify the one that did not rhyme (rhyme detection task requiring the selection of an ''odd one out''). The PIPA_AA assesses children's ability to compare the similarity of onsets and segment words at an intra-syllabic level. The examiner named each of four pictures and the children were asked to identify one that did not have the same initial sound as the others.

6.2.6.2 Output processing skills

G. *"Can the child access accurate motor programs?"* This level is tested by picture naming tasks to determine the accuracy of a child's stored motor program for words. Processing starts with the child's recognition of the picture followed by activation of and access to the stored 'semantic representations' where the lexicon is retrieved and continues to the stored motor program and the associated subsequent speech output processing routes. Children's performance on the TPT and DEAP were used to answer this question. Children were presented with a series of familiar pictures and required to name them without the benefit of a spoken model or speech input.

H. *"Can the child manipulate phonological units?"* This level aims to investigate a child's ability to manipulate existing motor program typically involving a task of phonological awareness that requires a child to manipulate phonological units at the syllable and phonemic levels respectively. The subtests of Syllable (PIPA_SSeg) and Phoneme Segmentation (PIPA_PS) as well as Phoneme Isolation (PIPA_PI) were used to answer this question. The PIPA_SSeg assessed children's ability to process words at a sub-lexical level. They were required to listen to unfamiliar words with varying syllable length and break them up into syllables. The PIPA_PS assessed children's ability to segment words heard into their individual phonemes. The PIPA_PI assessed children's ability to recognise and isolate onsets from rimes by saying the first sound of the word. The examiner named each picture stimuli and required the children to identify the first sound by producing it.

I. *"Can the child articulate real words accurately?"* This level usually involves imitation of real words that may not be familiar because it is concerned with a child's ability to produce real words without necessarily having to access stored representation of the words. Although this was not directly tested on all children, those who were not able to name any picture on the TPT and DEAP were given the verbal model for it to elicit a verbal imitation and check for stimulability.

J. *"Can the child articulate speech without reference to lexical representations?"* This level focuses on a child's ability to perform functional, non-linguistic tasks. The TENR-R was used to address this question. As previously noted, non-word repetition tasks require children to repeat non-words of an increasing number of consonants or syllable length that they just heard. Because non-words (or new words) do not exist in the stored representations speech input bypasses access to lexical representation towards motor programming where stored phonological units are selected and onwards to activate a motor program where the various gestural targets and motor sequences are assembled (taking acoustic variability into account) for a new representation in real time during speech production (Stackhouse & Wells, 1997). So while stored motor programs are central to naming tasks, online motor programming is central to non-word repetition tasks.

K. *"Does the child have adequate sound production skills?"* Information with regards to a child's oro-motor speech and structural integrity were acquired through observation and question asked of parents regarding their concern about their child's speech difficulties.

The PIPA_RA, PIPA_AA, and PIPA_ PI involved the use of highly imageable pictures and simple words. These factors ensured that the subtests tested what they aimed to test without taxing memory. PIPA_RA and PIPA_AA also did not require verbal answers. Children were not penalised for inaccurate productions in PIPA_RA and PIPA_PS as long as their habitual errors were known. In this way, children with speech sound production difficulties were not disadvantaged.

6.3 Data Collection

Data collection occurred at different time-points when the children were aged 2;0, (24-30 months), aged 3;6 (42-48 months), and aged 5;0 (60-66 months). At age 2;0, a pack consisting of an information sheet about the study, a parent questionnaire (PQ), a consent form, and a copy of the MacArthur-Bates Communicative Development Inventory: Words & Sentences (CDI) (Fenson et al., 2007) that has been adapted for NZ (Reese & Reid, 2000) was sent to parents who had indicated their interest in participating. Parents were given a choice to either return the completed documents by mail or to bring them to the first assessment session which followed, on average, after two weeks.

Most children attended two sessions of assessment at age 2;0, age 3;6 and age 5;0. At each session, a battery of selected assessments was administered by examiners who were also qualified speech-language pathologists (including the author at Time 4). Each child was assessed in a quiet laboratory playroom designed for participant testing and data collection at the Child Language Centre of the University of Canterbury. The children were tested individually with one parent or caregiver present at each session which lasted between 45 to 60 minutes at age 2;0 and age 3;6, and between 60 to 90 minutes at age 5;0, with breaks given as needed. All tests were administered according to published procedures. Child responses to the TPT and DEAP were transcribed in situ to test forms by the examiners. Sessions were audio-visually recorded in order to obtain as many contextual cues to help establish an utterance or speech sound produced, as well as for the purpose of verifying scoring accuracy. Parental consent was given for all children in the study.

6.4 Data analyses

The examiners scored children's responses to the standardised tests of language (PLS4 and CELFP2), from which standard scores and percentile ranks were derived according to the published procedures of each test. Using the video recordings, the author transcribed all of the children's responses on the TPT, DEAP, and TENR-R (except

TENR-R for age 3;6, which was scored by another post-graduate research student). The author was mindful that with picture-naming tasks, prior knowledge of a production's meaning could influence transcription, so caution was observed to transcribe productions as perceived rather than assumed (Howard & Heselwood, 2002).

Participants' speech sound productions were transcribed and analysed according to conventions described in the program manual of Phon (Rose et al., 2006). The test stimulus items for the TENR-R, TPT and DEAP were entered ('IPA Target') into Phon, as was the child's responses ('IPA Actual'). Phon was then used to compare each phoneme in 'IPA Targets' with the corresponding phoneme in the 'IPA Actuals', and to generate scores for the relevant outcomes. For the purpose of calculating scores on a standardized single-word articulation test, the use of broad transcriptions was deemed adequate with reference to Ladefoged's allophonic rules (Ladefoged & Johnson, 2014). However in order to obtain a statistically useful phonological analysis, it is necessary to ensure that the transcription does not overestimate a participant's phonological abilities. Hence where productions did not follow adult patterns or have uncommon phonetic behaviours, narrow transcription diacritics were used (Stoel-Gammon, 2001).

The following decisions regarding transcriptions were made in the interest of measuring inter-rater and intra-rater agreement, and for allowing for consistent comparison of data across tests and time-points while adhering to the published scoring conventions of the TPT, DEAP, and TENR-R, as well as conventions for the use of Phon to generate scores.

6.4.1 Conventions for transcribing the TPT and DEAP

1. All productions that could be perceived confidently after at least four replays (Olswang, Stoel-Gammon, Coggins, & Carpenter, 1987) were transcribed, even if they were produced simultaneously with any other extraneous sound captured on the recording.
2. Productions of whole words that were not easily transcribed after listening to them at least four times (for example due to impeded clarity of production such as

background noise, or poor intelligibility such as mumbling), were not transcribed. The "Exclude from searches" option in Phon was selected to exclude the target from being scored. On the other hand, productions of *part* of a word (phoneme / syllable) that could not be transcribed confidently were transcribed with the symbol '*' (Rose et al., 2006; Rose & MacWhinney, 2014) for each corresponding phoneme in both IPA Target and IPA Actual. Phon will exclude these phonemes when scoring.

3. If a participant did not attempt the target/s due to poor compliance, the "Exclude from searches" option was also selected for the specific target/s. Similarly, this rule applied to targets that examiners did not test or attempted but discontinued.
4. Targets that were not attempted by a participant who was verified to be at the non-verbal stage were entered as an error (percentage scores for accuracy were zero).
5. If a participant spontaneously repeated a target word, the best production was taken; not the first production. However, only the first phoneme produced in a repetition e.g /w-w-web/, was transcribed (Shriberg & Kwiatkowski, 1982).
6. The transcriber could refer to the examiner's stored test form transcription for confirmation of phonemes produced that were not easily perceived auditorily or required a visual cue such as /θ/. This was especially necessary when the young participants were active and moved away from their seats or turned their faces away from the camera.
7. Where a syllable was in error (either by addition or omission), the syllable sequence produced by the participant was aligned as closely as possible to that of the target, using vowels to mark syllable segments (Dollaghan and Campbell, 1998).
8. The following productions were credited as correct and therefore were transcribed as if produced correctly (matches IPA Target) for the purpose of generating scores using Phon. However, actual production was transcribed in Phon's 'Notes' segment for reference.
    - Target phonemes may be produced "incorrectly" but recognized as phonemes in the language, such as a lisp, lateralised /s/ or /z/, and lengthened stops or nasals.

- Vocalised final /l/ and glottalised final /t/ as they were acceptable variations in NZE (Bauer, 2007)
- The addition of an extra phoneme at the end of a target, such as for [pɪgi] for "pig," or [wɛbə] for "web". However, an addition of a schwa between clusters was taken as a cluster production error and transcribed as produced.
- Substitutions of cognates because of limited reliability in the transcription of voicing (Shriberg & Lohmeier, 2008).

6.4.2 Conventions for transcribing the TENR-R

Transcribing and scoring conventions for the TENR-R were similar to those for the TPT and DEAP described above with the exception that responses that contained common or habitual phonological processes (as noted from TPT and DEAP transcriptions), if consistently evidenced throughout the TENR-R, were transcribed in IPA Actual as if they were produced correctly in order to facilitate generating scores using Phon. For example, if as assessed on the TPT or DEAP a child habitually substituted /k/ with /t/ or /g/ with /d/, a production of [tɐ͜ʉdə] for the stimulus item /kɐ͜ʉgə/ was considered correct and therefore transcribed as /kɐ͜ʉgə/ in Phon. The participant's actual production [tɐ͜ʉdə] was then transcribed in the 'Notes' segment of Phon for reference.

6.4.3 Coding and Transcription Agreement

From the age 2;0 (N=29) and age 3;6 (N=22) TENR-R recordings a sample of 20% was randomly selected and independently transcribed by two trained transcribers (experienced speech-language therapists) who were blind to the purposes of the study. Inter-rater agreement on the correctness of phonemes transcribed was estimated based on a point-to-point system. The transcriptions of participants' responses were compared to that of the corresponding target non-words. Although broad transcription was mostly used, judgments on transcribers' agreement were weighed according to whether each phoneme met one of three criteria: identical, functionally equivalent or nearly functionally equivalent, as recommended by (Shriberg, Kent, & Munson, 2013) where needed. The resulting agreement percentages obtained for age 2;0 were 87.12% for consonants, 88.06% for vowels and 87.53% for the total. For age 3;6, the percentages of agreement obtained were 80% for consonants, 83.24% for vowels and 81.45% for the total.

6.4.4 Scoring of Percentage of Consonants Correct (PCC)

Phon contains an array of functions specifically designed to facilitate the study of child phonology, including one dedicated for PCC calculation. Phon, however, derives a PCC value for each individual utterance. Because PCC as a summary measure computed across a complete set of utterances for each child was more of relevance to the current study, PCC results generated in Phon were saved into a CSV file, where the total PCC for each child was calculated.

6.5 Statistical analyses

This section discusses the actions taken to safeguard the integrity and appropriateness of the data, before the data were used in statistical analyses.

6.5.1 Diagnostics steps

The dataset was first checked for accuracy of data coding and entry into the statistical program (SPSS version 22) by analysing frequencies, descriptive statistics and inspecting box-plots for outliers and extreme values for the full sample and subgroups of typically developing (TD) children and late talkers (LTs). These steps were necessary to ensure a valid data set for analysis, as the presence of outliers could violate the assumption of normal distribution. Prior to taking action on extreme values and outliers, the relevant scoring forms and portions of session recordings were referred to again because often outliers contain valuable information about the data gathering process and factors affecting it such as challenging behaviours. Following these steps, it was decided that extreme values from one child from the TD group was removed. He was diagnosed with ASD after age 2;0 and did not participate at age 3;6. Extreme values from LTs data were retained because in the LTs group outliers may represent real variation.

6.5.2 Missing Values

Variations in sample-size of various variables at each time point were noted due to missing values. These missing values can be attributed to several factors. First, participant attrition has been reported in many longitudinal studies. Second, while the examiners attempted every assessment measure with each child at every session, some were incomplete due to behaviour such as waning compliance and/or interest despite the offer of rewards, mostly with the toddlers at age 2;0. Third, some recordings were either disrupted by technical faults or poor audio quality. However, as mentioned in the previous chapter on Methodology, a distinction was made with regards to children's speech samples, between inconsistent and no response by children who were at the nonverbal / babbling stage of communication and not producing many words. Their responses were regarded as inaccurate and were scored as zero rather than as missing value. Table 6.3 presents the percentage of missing data for each of the variables at every time point. Finally, raw scores were used for analyses while standard scores (SS) were used for comparison with normative test data.

Table 6.3

Percentage of missing values for each variable at every time point

Variables at age 2;0 (N=168)	No. completed	% missing
PLS4_AC	168	0
PLS4_EC	168	0
TPT_PCC	158	6
TENR_PCC	156	8
Variables at age 3;6 (N=160)	No. completed	% missing
PLS4_AC	159	1
PLS4_EC	158	1
DEAP_PCC	156	3
TENR_PCC	156	3
Variables at age 5;0 (N=113)	No. completed	% missing
CELFP2_RLI	112	1
CELFP2_ELI	112	1
DEAP_PCC	110	3
TENR_PCC	111	2
PIPA_Total	108	5
CELFP2_EV	112	1
CELFP2_RS	112	1
PIPA_SSeg	107	6
PIPA_RA	109	4
PIPA_AA	107	6
PIPA_PI	107	6
PIPA_PS	109	4

Note. PLS4=Preschool Language Scale, Fourth Edition (Australian Language Adapted); AC=Auditory Comprehension; EC=Expressive Communication; TPT=Toddler Phonology Test; DEAP=Diagnostic Test of Articulation & Phonology; TENR-R=Test of Early Non-word Repetition-Revised; PCC=Percentage of Consonants Correct; CELFP2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RLI=Receptive Language Index; ELI=Expressive Language Index; SS=Standard Score; PIPA=Primary Inventory of Phonological Awareness; RA= Rhyme Awareness; AA=Alliteration Awareness; PI=Phoneme Isolation; PS=Phoneme Segment.

CHAPTER 7 RESULTS

The present study examined the development of phonology and the lexicon within the context of a prospective longitudinal study as observed in a cohort of toddlers with typically and late developing language over 18 months intervals when they were aged 2;0, 3;6 and 5;0 years. The study aimed to answer two principal questions; (1) Does a similar relationship between LTs' phonological and lexical systems exist as in TD children, and does this relationship change over time? (2) Do underlying impairments in their phonological systems contribute to early expressive language delay and persistence at outcomes? To arrive at the answers to the principal questions, three sub questions were posed.

This section begins with the descriptive statistics for the TD and LT groups followed by the results of the statistical analyses conducted to answer the sub questions. These included results for concurrent correlations between variables (section 7.2), comparison of group means (section 7.3), and contribution of measures of phonological accuracy to the proportion of variance accounted for in concurrent language outcomes (section 7.4). Interpretation and discussion of findings are found in Chapter 8.

7.1 Descriptive statistics

The number of participants varied at different time-points mainly as a result of attrition. At age 2;0 the sample size was 168 comprising 96 boys and 72 girls ranging from 24 to 31 months of age (*M* = 26.85, *SD* = 1.82). Out of the 168 families who had participated at age 2;0, 160 (95%) continued their participation at age 3;6. The participants made up of 69 girls and 91 boys and ranging from 42 to 50 months in age (*M* = 45.57, *SD* = 1.89). Finally at age 5;0, a total of 114 families returned and continued their participation (68% of those who had participated at age 2;0 and 71% of those seen at age 3;6. There were 60 boys and 54 girls whose ages ranged between 59 and 68 months (*M* = 63.34, *SD* = 2.01). Of the remaining, 21% did not respond to our emails, 3% had moved out of Christchurch, 2% were not able to participate due to reasons such as parents' poor health, and planned months-long vacation overseas, and finally 4% were not contactable due to inactive email accounts and/or phone numbers.

7.1.1 Assessment scores for TD children and LTs

Recall that children classified as later talkers at age 2;0 met the criteria of having low vocabulary (scoring at or below the 10th percentile of children in New Zealand) or parent report of no word combinations on the NZ CDI: WS words. By this definition, 50 participants make up the LT group out of the 168 in the full cohort, which is 30% of the entire sample, compared with the estimated 10 - 20% reported in previous studies (Klee et al., 1998; Reilly et al., 2007; Rescorla, 1989; Rescorla & Achenbach, 2002). Tables 7.1 and 7.2 present the resulting descriptive statistics for each group's assessment measures at every time point. Findings revealed developmental changes for the cohort such that as children's ages increased their mean scores for each measure also increased. At age 2;0 12 children were not yet imitating words generating 0 scores for the TENR-R and scores as low as 5 for the TPT. Table 7.4 presents the number and percentages of children from the TD and LT groups who scored either within or below the average when compared against normative test data.

7.1.1.1 Language measures

At age 2;0, all of the TD children had standard scores that were within the average range on the PLS4, except for three who scored below average on the subtest of auditory comprehension. At age 3;6, all of the TD children (except one) had average scores for both auditory comprehension and expressive language. Finally at age 5;0, all but two TD children had average receptive and expressive language indices scores. In contrast, at age 2;0 about half of the LTs scored within the average range for expressive language and around 34% had delayed auditory comprehension scores. At age 3;6, 96% of the LTs had average auditory comprehension scores and 87% had average expressive language scores. At age 5;0, a similar portion of the group (94% each) achieved receptive and expressive language scores that fell within average range.

7.1.1.2 Phonological accuracy

At age 2;0, all TD children had age-appropriate standard scores on the test of phonology. At age 3;6 however, nine in the group evidenced delayed acquisition. At age 5;0, the percentage of those who evidenced delayed phonological development rose to 22% (from previous 8%). Although speech delay in preschoolers with histories of typical language development is commonly observed in clinical settings, the percentage observed in the current study is an unexpected finding as they were higher than estimates reported by prevalence studies of preschoolers presenting with speech impairment. The estimated prevalence is 3.4% in Australian 4-year olds (Eadie et al., 2014), whereas in 6 year olds, the estimated prevalence is 5% in NZ (Gillon & Schwarz, 1999), 3.8% in the US (Shriberg, Tomblin, & McSweeny, 1999); 6.4% in the UK (Broomfield & Dodd, 2004), 2004). Because the TENR-R was not normed, percentile ranking were calculated based on data from the TD sample to facilitate making comparisons. To be consistent, scores that fall at or above the 16th percentile were considered 'average' (Table 7.4).

Table 7.1

Descriptive statistics for TD children: assessment measures

Variables	N	Range	Min	Max	M	SD
Age 24-30 months	118	6	24	30	26.96	1.76
CDIwords	114	574	85	659	417.82	132.16
PLS4_AC	118	28	22	50	36.29	5.42
PLS4_AC_SS	118	75	75	150	113.80	14.17
PLS4_EC	118	24	28	52	39.90	5.07
PLS4_EC_SS	118	63	87	150	119.35	15.96
TPT_PCC	108	66	25	91	67.48	13.04
TPT_PCC_SS	108	5	7	12	10.02	1.14
TENR-R_PCC	106	86	0	86	41.74	22.65
Age 42-50 months	113	8	42	50	45.64	1.91
PLS4_AC	113	25	37	62	53.34	4.33
PLS4_AC_SS	113	61	84	145	118.83	11.29
PLS4_EC	112	23	43	66	57.82	4.44
PLS4_EC_SS	112	54	94	148	124.04	11.67
DEAP_PCC	112	58	42	100	84.60	10.39
DEAP_PCC_SS	112	14	3	17	10.2	2.81
TENR_PCC	112	69	31	100	77.15	12.53
Age 59 – 68 months	81	9	59	68	63.49	2.05
CELFP2_RLI	81	28	35	63	54.60	5.36
CELFP2_RLI_SS	81	57	79	136	111.49	12.58
CELFP2_ELI	81	61	38	99	79.22	12.66
CELFP2_ELI_SS	81	65	77	142	113.26	13.57
DEAP_PCC	80	29	71	100	94.35	6.13
DEAP_PCC_SS	80	13	3	13	9.76	3.78
TENR_PCC	81	24	76	100	92.49	5.21
PIPA_Total	79	51	7	58	36.20	11.30

Note. CDI=MacArthur Bates-Communicative Development Inventory; PLS4=Preschool Language Scale, Fourth Edition (Australian Language Adapted); AC=Auditory Comprehension; EC=Expressive Communication; SS=Standard Score; TPT=Toddler Phonology Test; DEAP=Diagnostic Test of Articulation & Phonology; TENR-R=Test of Early Non-word Repetition-Revised; PCC=Percentage of Consonants Correct; CELF-P2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RLI=Receptive Language Index; ELI=Expressive Language Index; SS=Standard Score; PIPA=Primary Inventory of Phonological Awareness.

Table 7.2

Descriptive statistics for LTs: assessment measures

Variables	N	Range	Min	Max	M	SD
Age 24-30 months	50	7	24	31	26.58	1.95
CDIwords	46	292	2	294	70.61	65.56
PLS4_AC	50	21	18	39	28.84	5.20
PLS4_AC_SS	50	70	53	123	91.88	17.19
PLS4_EC	50	19	19	38	27.54	4.09
PLS4_EC_SS	50	49	65	114	83.92	10.24
TPT_PCC	50	83	0	83	22.72	25.26
TPT_PCC_SS		8	3	11	5.62	2.76
TENR-R_PCC	50	42	0	42	6.61	10.22
Age 42-50 months	45	8	42	50	45.40	1.83
PLS4_AC	46	23	35	58	48.98	4.96
PLS4_AC_SS	46	57	78	135	108.26	12.66
PLS4_EC	46	30	32	62	50.70	7.07
PLS4_EC_SS	46	68	71	139	107.74	15.74
DEAP_PCC	44	57	38	94	71.32	12.61
DEAP_PCC_SS	44	10	3	13	6.66	3.02
TENR_PCC	45	75	14	89	57.86	19.00
Age 59 – 68 months	32	8	59	67	62.94	1.88
CELFP2_RLI	31	27	33	60	51.03	7.25
CELFP2_RLI_SS	31	52	76	128	105	14.36
CELFP2_ELI	31	60	24	84	65.55	13.58
CELFP2_ELI_SS	31	51	66	117	100.06	12.40
DEAP_PCC	30	24	76	100	88.94	7.30
DEAP_PCC_SS	30	15	0	15	6.21	4.06
TENR_PCC	30	30	67	97	85.25	8.27
PIPA_Total	29	44	3	47	29.41	11.28

Note. CDI=MacArthur Bates-Communicative Development Inventory; PLS4=Preschool Language Scale, Fourth Edition (Australian Language Adapted); AC=Auditory Comprehension; EC=Expressive Communication; SS=Standard Score; TPT=Toddler Phonology Test; DEAP=Diagnostic Test of Articulation & Phonology; TENR-R=Test of Early Non-word Repetition-Revised; PCC=Percentage of Consonants Correct; CELF-P2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RLI=Receptive Language Index; ELI=Expressive Language Index; SS=Standard Score; PIPA=Primary Inventory of Phonological Awareness.

Table 7.3

Descriptive statistics for age 5;0 measures of phonological awareness

	TD children					
Age 5;0	N	Range	Min	Max	M	SD
PIPA_RA_SS	79	11	3	14	9.04	2.93
PIPA_AA_SS	79	12	4	16	11.87	3.10
PIPA_PS_SS	79	10	7	17	11.78	3.40
PIPA_PI_SS	78	12	4	16	13.59	2.66
PIPA_SSeg_SS	79	12	3	15	10.28	3.67
	LTs					
Age 5;0	N	Range	Min	Max	M	SD
PIPA_RA_SS	30	9	4	13	7.83	2.73
PIPA_AA_SS	28	13	3	16	10.86	3.36
PIPA_PS_SS	29	9	7	16	9.41	2.65
PIPA_PI_SS	29	13	3	16	12.31	3.42
PIPA_SSeg_SS	28	12	3	15	10.86	2.81

Note. PIPA=Primary Inventory of Phonological Awareness; RA=Rhyme Awareness, AA= Alliteration Awareness; PS=Phoneme Segment; PI=Phoneme Isolation; SSeg=Syllable Segment; CELFP2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RS=Recalling Sentences; EV=Expressive Vocabulary; DEAP=Diagnostic Test of Articulation & Phonology; TENR-R=Test of Early Non-word Repetition-Revised; PCC=Percentage of Consonants Correct; SS=Standard Scaled Scores

Table 7.4

Numbers and percentages of children with average and delayed scores*

	TD children		LTs	
Age 2;0	Average	Delayed	Average	Delayed
PLS4_AC_SS	115 (98%)	3 (3%)	33 (66%)	17 (34%)
PLS4_EC_SS	118 (100%)	0	26 (52%)	24 (48%)
TPT_PCC_SS	108 (100%)	0	24 (49%)	26 (51%)
TENR-R_PCC	90 (85%)	16 (15%)	7 (14%)	43 (86%)
Age 3;6	Average	Delayed	Average	Delayed
PLS4_AC_SS	112 (99%)	1 (1%)	44 (96%)	2 (4%)
PLS4_EC_SS	112 (100%)	0	40 (87%)	6 (13%)
DEAP_PCC_SS	103 (92%)	9 (8%)	23 (52%)	21 (48%)
TENR-R_PCC	94 (84%)	18 (16%)	17 (38%)	28 (62%)
Age 5;0	Average	Delayed	Average	Delayed
CELFP2_RLI_SS	78 (96%)	3 (4%)	29 (94%)	2 (6%)
CELFP2_ELI_SS	79 (98%)	2 (2%)	29 (94%)	2 (6%)
DEAP_PCC_SS	62 (78%)	18 (22%)	14 (47%)	16 (52%)
TENR-R_PCC	68 (84%)	13 (16%)	13 (43%)	17 (57%)

Note. *PLS4=Preschool Language Scale, Fourth Edition (Australian Language Adapted); AC=Auditory Comprehension; EC=Expressive Communication; SS=Standard Score; TPT=Toddler Phonology Test; DEAP=Diagnostic Test of Articulation & Phonology; PCC=Percentage of Consonants Correct; CELFP2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RLI=Receptive Language Index; ELI=Expressive Language Index;* SS $\geq$ 16th percentile*

7.1.2 Children's profiles and tracking changes over time

Earlier studies have identified variation in LTs' receptive-expressive language abilities with or without use of communicative gestures as well as in areas of phonology and grammar (Dale et al., 2003; Desmarais et al., 2008; Fischel, Whitehurst, Caulfield, & DeBaryshe, 1989). For the current cohort, individual participants from each group were first assigned into one of the following categories in accordance with the normative data provided by the standardised assessments: TSL (typical speech, receptive and expressive language), SD (speech delay only), ELD (expressive language delay only), SLD (speech and receptive and/or expressive language delay). The term 'Speech Delay' is used to describe children who score below the average range (scaled score less than 7) based on normative data of the TPT and DEAP. Children with standard scores of less than 85 or percentile ranks less than 16 for either auditory comprehension or expressive language were classified as language delayed. Next, for the purpose of tracking shifts in classification categories, only children whose data for all measures were available for at least age 2;0 and age 3;6, and whose profiles changed across time points were selected. As a result, changes in the profiles of 16 TD children were tracked at age 3;6 and age 5;0. The profiles of 44 LTs were tracked at age 3;6, but only 29 out of 44 LTs at age 5;0 (see Figures 7.1 and 7.2). Results support previous findings and the notion that the LTs in this cohort were not homogenous as a group; comprising subgroups with varying profiles and unstable trajectories in the development of different language domains. Although the same could be said of the TD group, the LTs in the current cohort were found to vary in their performance on tasks of phonology and expressive language from the start.

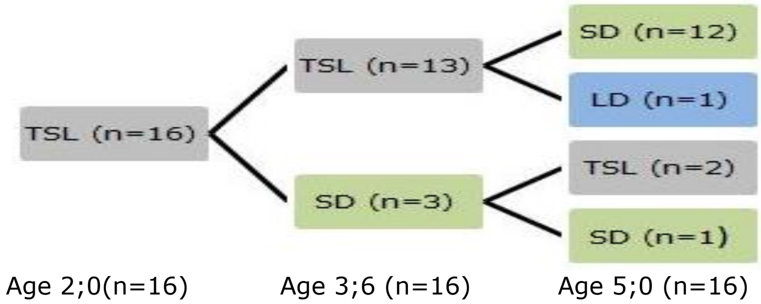

Figure 7.1. Tracking changes in profiles across time points: TD children who continued participation at each time point

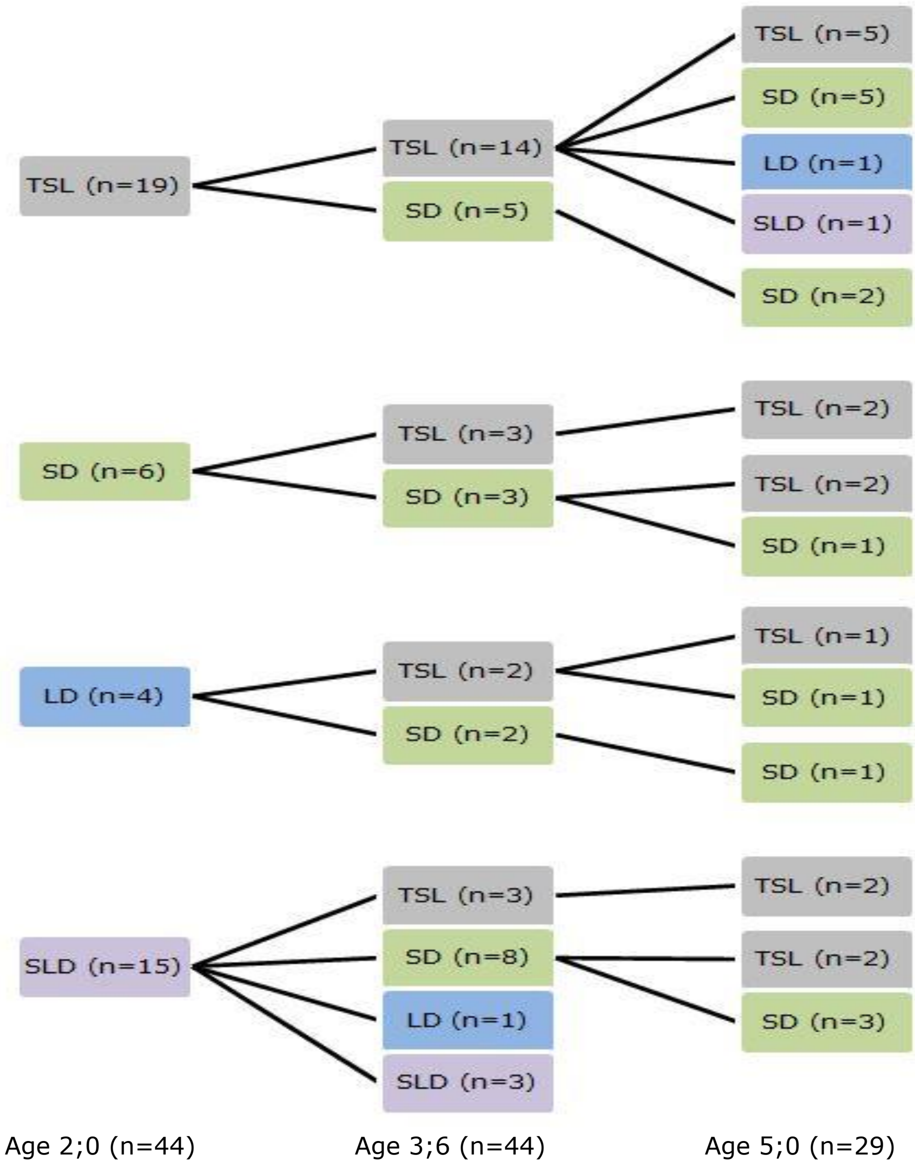

Figure 7.2. Tracking changes in profiles across time points: LTs who continued participation at each time point

7.1.3 Direction of change

The current study, as did others, found that memberships change across time. A noteworthy difference was that the current study was able to track the trajectories of children's skills across three time points until they were 5 years old to explore a pattern in membership change. When monitored based on their performances on the phonological accuracy for picture naming and expressive language, this study found a consistent pattern of change by age 5;0. In most TD children and LTs, resolution of a language delay preceded that of a speech / phonological delay, which in turn was followed by resolution in both domains of language. Any unresolved difficulty at age 5;0 was manifested predominantly as a specific Speech Delay. Both TD children and LTs appear to move along a continuum as depicted by Figure 7.3. At age 5;0, 'regression' from a profile of Typical Speech and Language was also observed in a few children. One TD child was categorised with Language Delay. Other studies have also identified language impaired children without a history of late talking (Dale et al., 1998; Poll & Miller, 2013; Rice, Taylor, & Zubrick, 2008). Among the LTs, one had Language Delay and another, Speech and Language Delay. These children are expected to improve along the continuum.

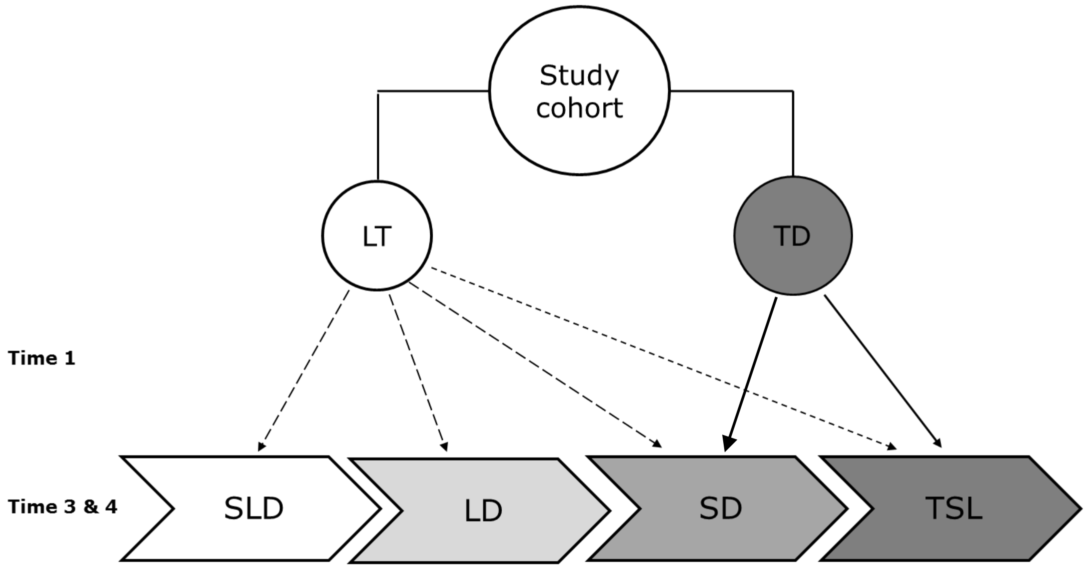

Figure 7.3. Direction of profile change

7.2 Sub question 1

Is there a statistically significant correlation between individual measures of phonology and language at each time-point for TD children? Does a similar relationship exist at the same time-points for LTs? Given these findings, are there observable across-group differences? It was hypothesised that significant bivariate correlations would be found between expressive language and individual measures of phonological accuracy (percentage consonant correct for picture naming and non-word repetition) for both TD children and LTs especially at age 2;0, when the lexicon is at an earlier stage of development.

To answer these questions, a Pearson product-moment correlation coefficient was computed to assess the relationship between the percentages of consonants correct and scores for expressive language at all time-points for the subgroups. In order to ensure consistency, interpretation of the magnitude or strength of effect sizes of a correlation coefficient was made according to guidelines provided by Cohen (1988). Correlation coefficients in the order of .10 were considered to be small (weak), those of .30 and above were medium (moderate) and those of .50 and above were large (strong). Bivariate correlations among variables are shown in Tables 7.5 and 7.6. Given the high correlations between CDIWords and PLS4_EC, the terms lexicon and expressive language are used interchangeably from now on.

7.2.1 Concurrent correlations each time point: TD children

At age 2;0 there were significant, positive, moderate correlations between TPT_PCC_T1 and PLS4_EC_T1, $r(104) = .45$; $p < .001$, as well as between TENR-R_PCC and PLS4_EC_T1, $r(104) = .48$; $p < .001$ (Figure 7.4). Increases in the percentages of consonants correct for both picture naming and non-word repetition tasks were moderately associated with increases in the expressive language scores of typically developing toddlers.

At age 3;6 there were significant, positive, moderate correlations between DEAP_PCC_T3 and PLS4_EC_T3, $r(109) = .26$; $p = .007$, as well as between TENR-

R_PCC_T3 and PLS4_EC_T3 , $r(109) = .29$; $p = .002$ (Figure 7.4). Increases in percentages of consonants correct for both picture naming and non-word repetition tasks were moderately associated with increases in expressive language scores in children between the ages of 42 to 50 months.

At age 5;0 the association between DEAP_PCC_T4 and CELFP2_ELI_T4 was weak and not statistically significant, $r(78) = .13$, $p = .264$. However, there was a significant, positive and moderate correlation between TENR-R_PCC_T4 and CELFP2_ELI_T4, $r(79) = .38$, $p = .001$ (Figure 7.4). Increases in expressive language scores were not significantly associated with increases in the percentage of consonants correct for picture naming task, but they were moderately associated with increases in the percentage of consonants correct for non-word repetition tasks.

Regarding phonological awareness at age 5;0, the PIPA_Total_T4 had a significant, strong, positive correlation with CELFP2_ELI_T4, $r(77) = .61$, $p < .001$, significant, positive but weak correlation with the DEAP_PCC_T4, $r(76) = .23$, $p = .044$, but a significant, positive and moderate correlation with TENR-R_PCC_T4, $r(77) = .36$, $p = .001$. Increases in phonological awareness scores were more strongly associated with increases in expressive language scores than increases in the percentages of consonants correct for picture naming and non-word repetition tasks.

7.2.2 Concurrent correlations at each time point: LTs

At age 2;0 there were significant, positive, strong correlations between TPT_PCC_T1 and PLS4_EC_T1, $r(49) = .66$; $p < .001$, and between TENR-R_PCC_T1 and PLS4_EC_T1, $r(49) = .56$; $p < .001$ (Figure 7.4). Increases in the percentages of consonants correct for both picture naming and non-word repetition tasks were strongly associated with increases in expressive language scores in late talking toddlers.

At age 3;6 there was a significant, positive, moderate correlation between DEAP_PCC_T3 and PLS4_EC_T3, $r(42) = .32$; $p = .038$, but a significant, positive, and strong correlation between TENR-R_PCC_T3 and PLS4_EC_T3, $r(43) = .55$; $p < .001$ (Figure 7.4). Increases in expressive language scores were moderately associated with increases in the percentage of consonants correct for picture naming, but strongly associated with increases in the percentage of consonants correct for non-word repetition tasks.

At age 5;0 DEAP_PCC_T4 had an insignificant, positive, and weak correlation with CELFP2_ELI_T4, $r(28) = .24$, $p = .204$, but a significant, positive, strong correlations between TENR-R_PCC_T4 and CELFP2_ELI_T4, $r(28) = .69$, $p < .001$ (Figure 7.4). Increases in expressive language scores were insignificantly associated with increases in the percentage of consonants correct for picture naming tasks but strongly associated with increases in the percentage of consonants correct for non-word repetition task.

Regarding phonological awareness at age 5;0 PIPA_Total_T4 had a significant, positive and strong correlation with CELFP2_ELI_T4, $r(27) = .69$, $p < .001$, an insignificant correlation with DEAP_PCC_T4, $r(27) = .11$, $p = .587$, but a significant, positive and moderate correlation with the TENR-R_PCC_T4, $r(27) = .45$, $p = .015$. Increases in phonological awareness scores were more strongly associated with increases in expressive language scores than increases in the percentage of consonants correct for picture naming and non-word repetition tasks.

As hypothesised, significant bivariate correlations were found between individual measures of phonological accuracy and expressive language for both typically developing children and late talkers at age 2;0 where the lexicon is at the early stage of development.

Table 7.5 Bivariate correlations between measures across time point: TD children

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Age 2;0																					
1. CDIwords	-																				
2. PLS4_AC	.50**	-																			
3. PLS4_EC	.70**	.75**	-																		
4. TPT_PCC	.44**	.27**	.45**	-																	
5. TENR_PCC	.42**	.32**	.48**	.36**	-																
Age 3;6																					
6. PLS4_AC	.36**	.63**	.54**	.21*	0.19	-															
7. PLS4_EC	.37**	.53**	.50**	.26**	.33**	.78**	-														
8. DEAP_PCC	.34**	0.04	.28**	.66**	.27**	.21*	.26**	-													
9. TENR_PCC	.37**	.23*	.32**	.49**	.41**	.21*	.29**	.49**	-												
Age 5;0																					
10. CELFP2_RLI	.25*	.54**	.49**	0.19	.29*	.69**	.73**	.22*	0.09	-											
11. CELFP2_ELI	.45**	.56**	.60**	0.18	.30**	.70**	.72**	0.13	0.19	.74**	-										
12. DEAP_PCC	0.13	0.17	0.17	.32**	.31**	0.2	.35**	.48**	.33**	0.1	0.13	-									
13. TENR_PCC	.33**	.34**	.37**	.39**	.45**	.35**	.35**	.40**	.40**	.36**	.38**	.29**	-								
14. PIPA_Total	.44**	.49**	.57**	.33**	.38**	.57**	.55**	.41**	.36**	.64**	.61**	.23*	.36**	-							
15. CELFP2_EV	.30**	.47**	.43**	0.08	0.23	.54**	.55**	0.03	0.12	.52**	.81**	0.13	.27*	.43**	-						
16. CELFP2_RS	.49**	.51**	.61**	0.21	.34**	.63**	.61**	0.13	0.22	.65**	.91**	0.12	.42**	.63**	.56**	-					
17. PIPA_SSeg	0.22	0.22	.29*	0.12	0.21	.34**	.39**	.22*	0.07	.37**	.28*	-0.05	0.09	.58**	0.11	.34**	-				
18. PIPA_RA	.40**	.44**	.56**	.39**	.43**	.53**	.54**	.35**	.34**	.53**	.53**	0.21	.33**	.69**	.43**	.50**	0.2	-			
19. PIPA_AA	.42**	.47**	.54**	.32**	.39**	.53**	.49**	.34**	.33**	.59**	.61**	.25*	.45**	.85**	.43**	.62**	.30**	.58**	-		
20. PIPA_PI	.33**	.32**	.34**	0.18	0.09	.35**	.38**	.31**	.31**	.52**	.45**	0.15	.31**	.76**	.32**	.42**	.25*	.44**	.67**	-	
21. PIPA_PS	.24*	.31**	.29**	0.19	0.18	.31**	0.17	.27*	.26*	.27*	.25*	.25*	0.09	.67**	0.17	.32**	.24*	.31**	.47**	.38**	-

*Note. CDI= MacArthur Bates - Communicative Development Inventory; PLS4=Preschool Language Scale, Fourth Edition (Australian Language Adapted); AC=Auditory Comprehension; EC=Expressive Communication; TPT=Toddler Phonology Test; DEAP=Diagnostic Test of Articulation & Phonology; PCC=Percentage of Consonants Correct; CELFP2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RLI=Receptive Language Index; ELI=Expressive Language Index; PIPA=Primary Inventory of Phonological Awareness. **p<0.01; *p<0.05.*

Table 7.6 Bivariate correlations between measures across time points: LTs

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Age 2;0																					
1. CDIwords	-																				
2. PLS4_AC	.50**	-																			
3. PLS4_EC	.78**	.51**	-																		
4. TPT_PCC	.61**	.50**	.66**	-																	
5. TENR_PCC	.70**	.46**	.56**	.62**	-																
Age 3;6																					
6. PLS4_AC	.58**	.76**	.52**	.52**	.44**	-															
7. PLS4_EC	.55**	.59**	.47**	.47**	.37*	.83**	-														
8. DEAP_PCC	.35*	.40**	.34*	.50**	0.24	.33*	.32*	-													
9. TENR_PCC	0.28	.47**	0.29	.32*	0.22	.54**	.55**	0.28	-												
Age 5;0																					
10. CELFP2_RLI	0.13	.42*	0.19	0.35	0.32	.52**	.50**	0.11	0.29	-											
11. CELFP2_ELI	.38*	.59**	0.23	.45*	0.32	.80**	.81**	.47**	.46*	.64**	-										
12. DEAP_PCC	0.13	0.25	-0.01	0.08	0.09	0.13	0.14	0.31	.43*	-0.01	0.24	-									
13. TENR_PCC	.39*	.53**	0.25	0.29	0.23	.62**	.69**	.41*	.49**	0.33	.69**	0.31	-								
14. PIPA_Total	0.36	.59**	0.36	.42*	.38*	.67**	.56**	.38*	.48*	.78**	.68**	0.11	.45*	-							
15. CELFP2_EV	0.31	.37*	0.27	.36*	0.32	.69**	.60**	0.35	0.19	.43*	.75**	-0.05	.56**	.43*	-						
16. CELFP2_RS	.40*	.59**	0.22	.43*	0.24	.73**	.80**	.49**	.59**	.54**	.90**	.39*	.64**	.62**	.42*	-					
17. PIPA_SSeg	0.3	.57**	0.29	.40*	0.25	.59**	.45*	0.26	0.21	.53**	.56**	-0.03	.41*	.66**	0.25	.57**	-				
18. PIPA_RA	0.28	0.26	0.16	0.17	0.24	0.34	0.31	0.1	0.31	.41*	.43*	0.02	.39*	.62**	0.34	0.32	0.19	-			
19. PIPA_AA	0.3	.56**	0.36	.40*	.39*	.55**	.48*	.40*	.42*	.61**	.50**	0.15	.38*	.88**	.40*	.43*	.38*	.46*	-		
20. PIPA_PI	0.2	.48**	0.23	0.2	0.2	.51**	.47*	0.22	.45*	.78**	.64**	0.25	0.35	.85**	0.27	.66**	.55**	.39*	.75**	-	
21. PIPA_PS	0.12	.48**	0.16	0.32	0.29	0.36	0.36	0.24	0.03	.44*	0.36	0.14	0.21	.51**	0.33	0.28	.38*	0.12	.72**	.51**	-

*Note. CDI= MacArthur Bates - Communicative Development Inventory; PLS4=Preschool Language Scale, Fourth Edition (Australian Language Adapted); AC=Auditory Comprehension; EC=Expressive Communication; TPT=Toddler Phonology Test; DEAP=Diagnostic Test of Articulation & Phonology; PCC=Percentage of Consonants Correct; CELFP2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RLI=Receptive Language Index; ELI=Expressive Language Index; PIPA=Primary Inventory of Phonological Awareness. **p<0.01; *p<0.05.*

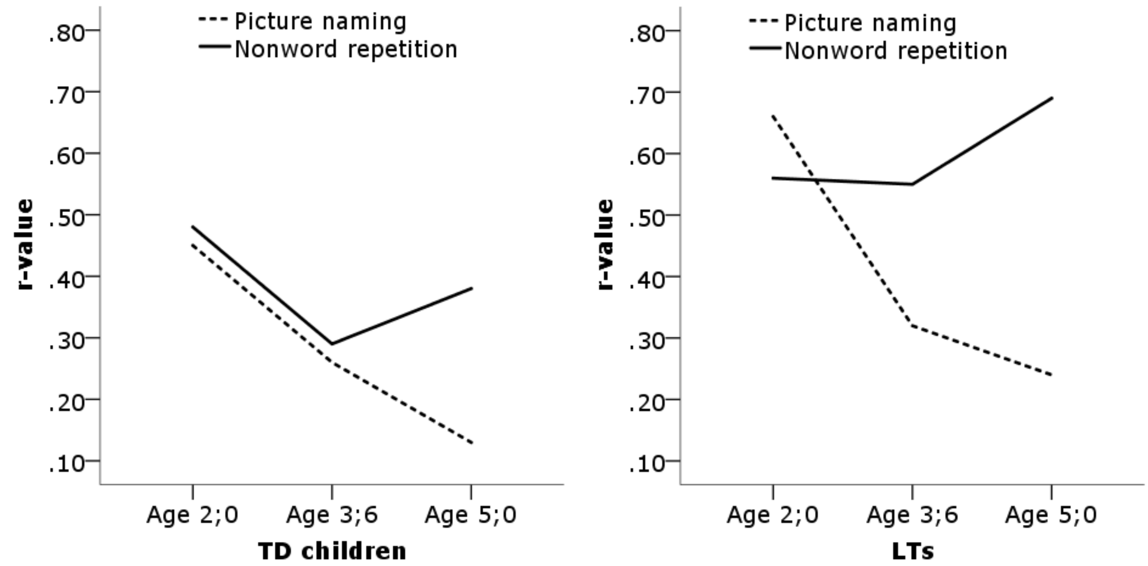

Figure 7.4. Correlations between measures of phonological accuracy and expressive language: Between TD and LT groups

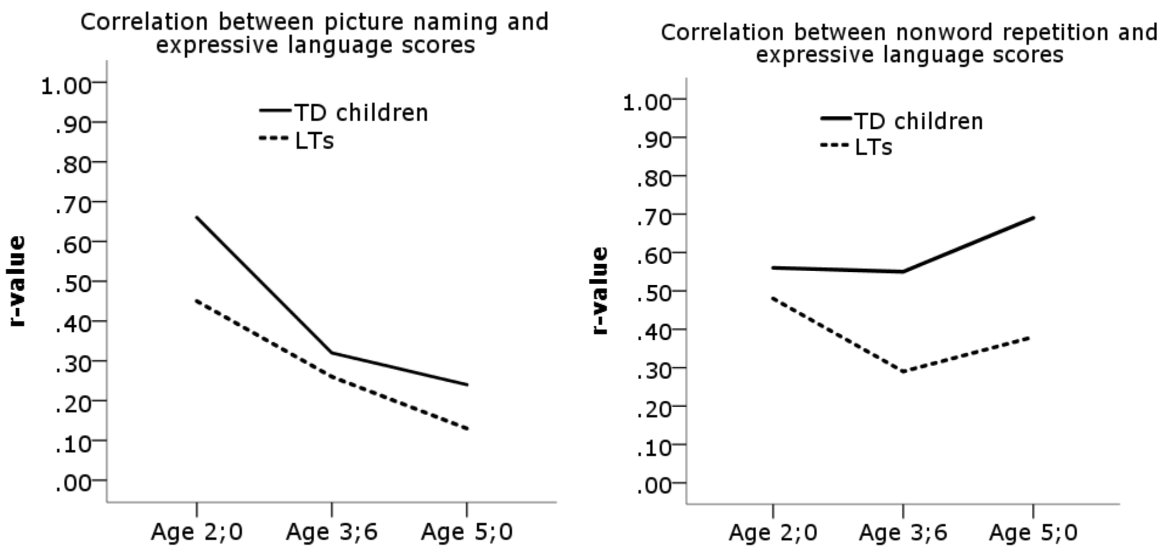

Figure 7.5. Correlations between individual measure of phonological accuracy and expressive language: Within TD and LT groups

7.3 Sub-question 2

I next asked whether there was a significant difference between the TD and LT groups on phonology and language at each time point. If so, do LTs show the same patterns of development as TD children with respect to the relationship between measures of phonology and language, albeit delayed? Significant differences were expected between mean scores for TD children and LTs for each measure at every time point, with significantly lower scores for LTs. At age 3;6 and age 5;0, the expressive language skills of 50%-75% of children with a history of late talker status were expected to resolve (i.e., fall within normal range) given the estimated 40% to 71% rates of resolution among LTs in previous studies (Dale et al., 2003; Paul, 1993; Rescorla, Dahlsgaard, et al., 2000). Figures 7.6, 7.7 and 7.8 are the graphical representations of the results of MANOVA analyses for each group at each time point.

7.3.1 Comparison of group means at age 2;0

Analyses of the differences in group means for phonological accuracy and language were conducted using a MANOVA analysis. Using Pillai's trace, results showed a significant difference between TD children and LTs when considered jointly on all three variables, $V = .678$, $F(3, 143) = 100.45$, $p < .001$. Given the significance of the overall test, the univariate main effects were examined. There was a significant difference between TD children and LTs on the TPT_PCC, $F(1, 145) = 195.41$, $p < .001$, with TD children ($M = 67$) scoring higher than LTs ($M = 23$), and on the TENR-R_PCC, $F(1, 145) = 124.25$, $p < .001$, with TD children ($M = 43$) scoring higher than LTs ($M = 7$), and on the PLS4_EC, $F(1, 145) = 244.32$, $p < .001$, with TD children ($M = 40$) scoring higher than LTs ($M = 28$).

7.3.2 Comparison of group means at age 3;6

Using Pillai's trace there was a significant difference between TD children and LTs when considered jointly on all three variables, $V = .363$, $F(3, 150) = 28.54$, $p < .001$. Given the significance of the overall test, the univariate main effects were also examined.

There was a significant difference between TD children and LTs on the DEAP_PCC, $F(1, 152) = 44.52$, $p < .001$, with TD children ($M = 85$) scoring higher than LTs ($M = 71$), the TENR-R_PCC , $F(1, 152) = 53.38$, $p < .001$, with TD children ($M = 77$) scoring higher than LTs ($M = 59$), and the PLS4_EC, $F(1, 152) = 49.93$, $p < .001$, with TD children ($M = 58$) scoring higher than LTs ($M = 51$).

7.3.3 Comparison of group means at age 5;0

Using Pillai's trace, there was a significant difference between TD children and LTs when considered jointly on all four variables, $V = .297$, $F(4, 102) = 10.76$, $p < .001$. Given the significance of the overall test, the univariate main effects were also examined. There was a significant difference between TD children and LTs on the DEAP_PCC, $F(1, 105) = 15.17$, $p = .001$, with TD children ($M = 94$) scoring higher than LTs ($M = 89$), the TENR-R_PCC, $F(1, 105) = 30.49$, $p < .001$, with TD children ($M = 93$) scoring higher than LTs ($M = 85$), on the PIPA_Total, $F(1, 105) = 7.63$, $p = .007$, with TD children ($M = 36$) scoring higher than LT ($M = 29$), and on the CELFP2_ELI, $F(1, 105) = 25.89$, $p < .001$, with TD children ($M = 80$) scoring higher than LTs ($M = 65$).

Group means on the measures of the speech processing profile were also compared. Using Pillai's trace, there was a significant difference between TD children and LTs when considered jointly on all variables, $V = .354$, $F(7, 97) = 10.76$, $p < .001$. Given the significance of the overall test, the univariate main effects were also examined. Results showed significant group differences on all variables except the PIPA_SSeg. LTs have significantly weaker speech processing skills compared to their TD peers (Table 7.5).

In summary, TD children consistently showed significantly better performances on all of measures at all time-points compared to LTs. At age 3;6, as their ages increased, both TD children and LTs achieved increased scores on each measure (albeit delayed for the LTs). Within groups, the pattern of increase in measures relative to each other was similar for TD children at all-time-points but only at age 3;6 and age 5;0 for LTs. Unlike for the TD children at age 2;0, the LTs' mean TPT_PCC and TENR-R_PCC scores lagged behind their PLS4_EC scores. With regards to specific measures for profiling of speech processing, the TD children and LTs performed significantly differently on most measures.

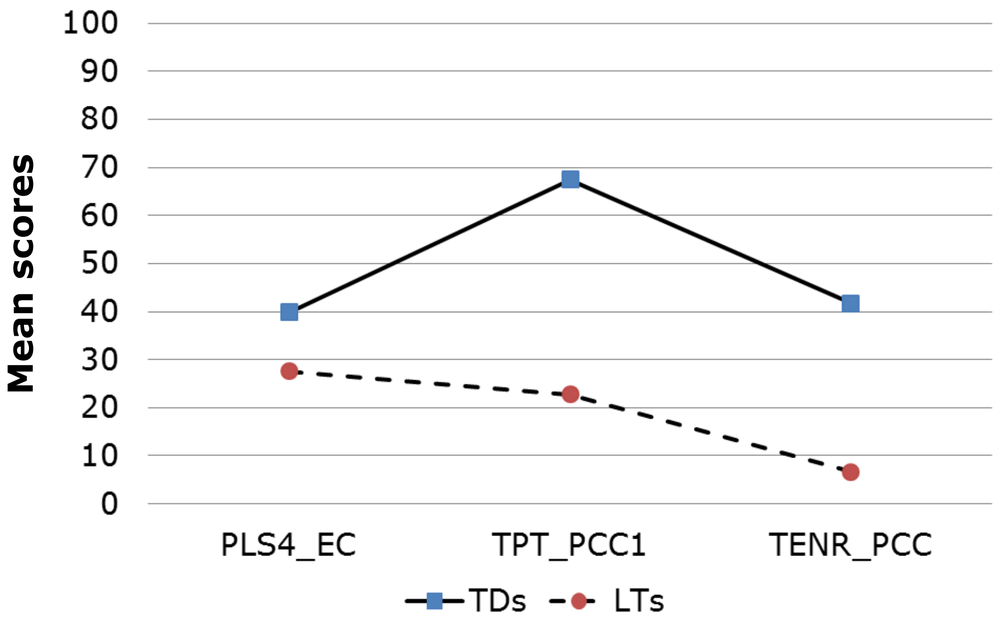

Figure 7.6. Comparison of group means: age 2;0 measures

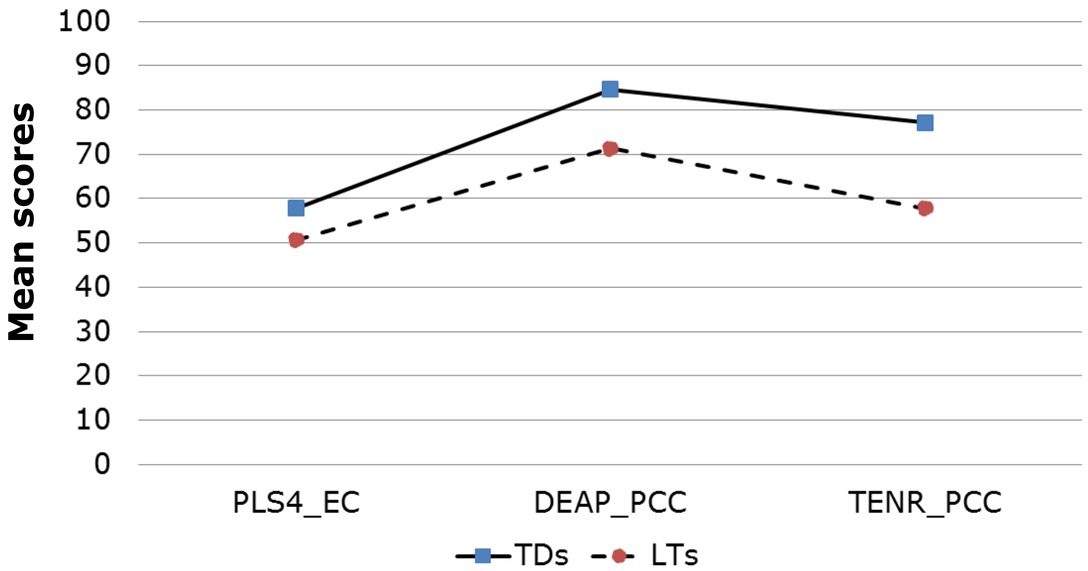

Figure 7.7. Comparison of group means: age 3;6 measures

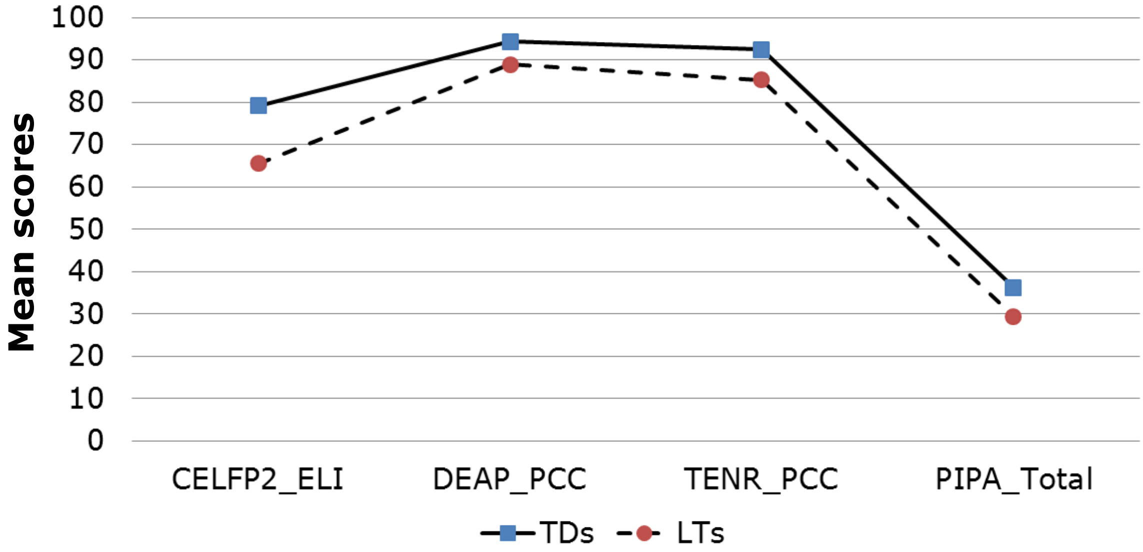

Figure 7.8. Comparison of group means: age 5;0 measures

Table 7.7

Comparison of group means: age 5;0 measures of speech processing

	TD children (N=77)		*LTs (N=28)*				
Measures*	*M*	*SD*	*M*	*SD*	*F*	*df*	*p*
PIPA_RA	7.53	2.89	6.21	2.59	4.50	1,103	.036
PIPA_AA	8.21	3.38	6.54	4.00	4.54	1,103	.035
DEAP_PCC	94.47	6.09	88.65	7.44	16.58	1,103	.000
PIPA_PS	2.83	3.10	.61	.96	13.88	1,103	.000
PIPA_PI	10.34	2.29	8.29	4.00	10.74	1,103	.001
PIPA_SSeg	7.73	3.64	8.18	2.92	.35	1,103	.556
TENR_PCC	92.66	5.18	85.09	8.54	30.15	1,103	.000

*Note. PIPA=Primary Inventory of Phonological Awareness; RA=Rhyme Awareness, AA= Alliteration Awareness; PS=Phoneme Segment; PI=Phoneme Isolation; SSeg=Syllable Segment; CELFP2=Clinical Evaluation of Language Fundamentals-Preschool, 2nd Edition; RS=Recalling Sentences; EV=Expressive Vocabulary; DEAP=Diagnostic Test of Articulation & Phonology; TENR-R=Test of Early Non-word Repetition-Revised; PCC=Percentage of Consonants Correct; * raw scores used.*

7.4 Sub Question 3

Following on from the correlation analyses of question 1, question 3 asked what proportion of variance in expressive language is explained by each measure of phonological accuracy in TD children and LTs?

At age 2;0, PCC scores for both picture naming and non-word repetition were hypothesised to make strong unique contributions to lexical and language development. The PCC for picture naming was hypothesised to have a more significant effect size for LTs due to either scarce phonological representations or poor speech output processing. Since speech-phonological processing must take place rapidly in real-time, it would not be surprising if this is a vulnerable system in LTs. Given current evidence, the PCC for non-word repetition was expected to continue to have an effect on expressive language development at age 3;6 and age 5;0.

Correlations by themselves however do not demonstrate how each independent variable contributed, if at all, to the outcomes. Linear regression analyses were conducted at each time-point to identify the relative contributions of PCC scores for picture naming and non-word repetition tasks to the proportions of variance explained in expressive language scores. Analyses of the residuals as well as visual inspection of histograms and normal Q-Q plots indicated that variables were approximately normally distributed for the full sample and subgroups. Analyses to test for assumptions of linearity and normality of distribution of scores underlying continuous variables of interest and examination of tolerance levels and multicollinearity among the independent variables showed that explanatory variables were sufficiently independent of one another.

7.4.1 Contribution to the proportion of variance: TD children

At age 2;0, independent variables TPT_PCC_T1 and TENR-R_PCC_T1 had a significant combined effect on and explained 30.4% of the variance in PLS4_EC_T1 scores, R^2 = .304, $F(2,94)$ = 20.5, p < .001. Both TPT_PCC_T1 and TENR-R_PCC_T1 made moderate and statistically significant unique contributions (β = .321, p < .001, and β = .347, p < .001, respectively).

At age 3;6, independent variables DEAP_PCC_T3 and TENR-R_PCC_T3 had a significant combined effect on and explained about 10% of the variance in PLS4_EC_T3 scores, R^2 = .099, F(2,107) = 5.88, p = .004. However, neither DEAP_PCC_T3 nor TENR-R_PCC_T3 made statistically significant unique contributions to the proportion of variance in PLS4_EC_T3 scores (β = .159, p = .133 and β = .205, p = .053, respectively).

At age 5;0, the independent variables had a significant combined effect and explained 14.3% of the variance in CELFP2_ELI_T4 scores, R^2 = .143, F(2,77) = 6.42, p = .003. Of these independent variables only the TENR-R_PCC_T4 made significant unique contribution (β = .373, p < .001), while the DEAP_PCC_T4 did not (β = .016, p = .882). When the PIPA_Total_T4 was added into the equation, the three independent variables had a significant combined effect and explained 39.8% of the variance in CELFP2_ELI_T4 scores, R^2 = .398, F(3,74) = 16.33, p < .001. Only PIPA_Total_T4 made a statistically significant unique contribution (β = .561, p < .001). Both TENR-R_PCC_T4 and DEAP_PCC_T4 did not (β = .173, p = .091 and β = -.049, p = .611, respectively).

7.4.2 Contribution to the proportion of variance: LTs

At age 2;0, the combined variables had a significant effect on and explained 46.5% of the variance in PLS4_EC_T1 scores, R^2 = .465, F(2,47) = 20.46, p < .001. TPT_PCC_T1 made a unique significant and strong contribution (β = .505, p = .001), whereas the contribution of the TENR-R_PCC_T1 was insignificant (β = .241, p = .084).

At age 3;6, independent variables DEAP_PCC_T3 and TENR-R_PCC_T3 also had a significant combined effect on and explained 27.6% of the variance in PLS4_EC_T3 scores, R^2 = .276, F(2,41) = 7.81, p = .001. While DEAP_PCC_T3's contribution was similarly not significant (β = .192, p = .173), the TENR-R_PCC_T3 was noted to make a moderate unique contribution (β = .438, p = .003).

At age 5;0, the two independent variables had a significant combined effect and explained 47.5% of the variance in CELFP2_ELI_T4 scores, R^2 = .475, $F(2,77)$ = 12.22, p < .001. Of these independent variables only the TENR-R_PCC_T4 made significant unique contribution (β = .681, p < .001), while the DEAP_PCC_T4 did not (β = .024, p = .870). When the PIPA_Total_T4 was added into the equation, the three independent variables had a significant combined effect on and explained 65.7% of the variance in CELFP2_ELI_T4 scores, R^2 = .657, $F(3,25)$ = 15.98, p < .001. Both PIPA_Total_T4 and TENR-R_PCC_T4 made similar unique contribution (β = .471, p = .001, and β = .470, p = .002), while DEAP_PCC_T4 did not (β = -.04, p = .751).

As hypothesised, late talkers' PCC for picture naming had a larger effect at Age 2;0 than at subsequent time points. Since speech processing must take place rapidly in real-time, late talkers were expected to have a vulnerable system.

CHAPTER 8 DISCUSSION

The study presented in this thesis aims to explore relationships between phonology and the lexicon in both typically developing and late talking children across development. It includes an investigation of the psycholinguistic processing mechanisms that support children's phonological development and how their strengths and weaknesses in processing may affect the phonology-lexical interaction. The study was motivated by the search for answers to two principal questions; (1) Does a similar relationship between LTs' phonological and lexical systems exist as in TD children and does this relationship change over time? (2) Do underlying impairments in their phonological systems contribute to early expressive lexical delay and persistence at outcomes? To arrive at the answers, the current study examined the growth trajectories in children's phonological and lexical development, in the context of a prospective longitudinal study over 18 months intervals when these children were approximately 2;0, 3;6 and 5;0 years old. This included an exploration of the interactions between underlying processes using a psycholinguistic framework for assessment.

In this chapter, the findings for Question 1 at every time point are discussed separately for TD children and LTs, followed by a comparison and interpretation of findings between the groups. The findings for Question 2 are discussed in the same format and examined using a psycholinguistic speech processing framework to suggest speech input and processing impairment/s that could account for the results. Direct comparison and interpretation of current findings with those of previous studies are limited due to differences in methods that include differences in criteria used to define sample sizes and composition, ages at intake and outcomes, LTs and later language impairment, constructs measured and measures used for the same constructs, as well as statistical analyses. Nevertheless, references to these studies are made where appropriate to facilitate interpretation. Finally, the overall findings of the study are summarized. This chapter ends with a discussion of the study's limitations and strengths, including implications for clinical practice and future research.

8.1 The relationship between phonology and the lexicon

Question 1 asked if a similar relationship between LTs' phonological and lexical / expressive language systems exist as seen in TD children and if this relationship changes over time. First, the relationship for TD children was examined.

8.1.1 Relationship in TD children over time

At age 2;0 TD children's phonological accuracy for picture naming and expressive language development were commensurate with norms obtained from the respective standardised tests. Correlations between individual measures of phonological accuracy and expressive language were comparable, with both relationships being significant at moderate levels of strength. Despite differences in samples and methods used, results were similar to previous findings in that children with more accurate phonological accuracy had larger vocabularies, indicating a relationship between the two domains for TD children. Previous studies also reported a positive and significant correlation between children's nonword repetition (NWR) accuracy and vocabulary size (Hoff, Core, & Bridges, 2008; Jones, 2016; Stokes & Klee, 2009b; Storkel, 2011).

Results also indicated that there was a relationship between TD children's phonological accuracy and their expressive language abilities at age 3;6 as a group. Their PCC in picture naming and expressive language development was commensurate and a majority of children (84%) also scored within average range for NWR. Correlations between expressive language scores and individual measures of phonological accuracy although continuing to be significant, reduced to low-moderate levels of strength. Of note, nine (8%) children from this group were found to display Speech Delay on the test of phonology. In these children, the development of their phonology and expressive language dissociated.

At age 5;0, their PCC in picture naming and expressive language were again commensurate with normative data and a majority (84%) again scored within average range for NWR. However, at this age only a weak correlation between expressive language and PCC in picture naming was noted. In contrast, correlation between expressive language and PCC in NWR strengthened. By this age, of the 81 TD children who continued participation at this time point, 21% were categorized with Speech Delay; all of these children were previously categorized under Typical Speech and Language at age 3;6, except one who was from the Speech Delay subgroup. One of the likely explanations for the high percentage found in the current study could be in the sample composition. There were 33 TD children at age 3;6 who did not participate at age 5;0. Out of these 33, only three had delayed phonological development while the rest had scores within the average range. Had these 33 children participated at age 5;0 and assumed to progress according to the pattern of profile change and obtained expressive language scores within average range, this would only reduce the percentage of those with delayed phonological development to 19% [(18+3)/112]. Therefore, it may be reasonable to conclude that parents who had concern about any aspect of their children's speech and language development were the ones more keen to continue participation at age 5;0.

Taken together, results indicate that TD children's phonological accuracy and expressive language skills were generally stable and commensurate with normative data across time points. With maturation, the group's mean scores increased for all measures. Consistently, a majority of children in the group (>80%) obtained NWR scores that were above the 16th percentile. Nonetheless, the pattern of correlations between measures differed across the developmental stages. The relationship between expressive language and PCC in picture naming consistently decreased from a moderate level of strength at age 2;0 to weak at age 3;6 and insignificant level at age 5;0. On the other hand, the strength of the correlation between expressive language with PCC in NWR was less stable; decreasing from age 2;0 to age 3;6 before increasing at age 5;0 (although within moderate levels). The emergence of Speech Delay at ages 3;6 and 5;0 suggests a dissociation between the development of phonology and expressive language in these children. Phonological delays are expected to resolve with development (Dodd et al., 2002; Shriberg et al., 2010). The process of accurate consonant production continues at age 7 (James, 2001) and is not expected to become adult-like until children are about 9-years old (Smit, Hand, Freilinger, Bernthal, & Bird, 1990). A recent population cohort study estimated that 3.6% of 8 year olds evidence persistent SSD (Wren, Miller, Peters, Emond, & Roulstone, 2016).

8.1.2 Relationship in LTs over time

At age 2;0 LTs' phonological accuracy and expressive language skills were commensurate but delayed according to normative data provided by respective standardised tests. This suggested evidence of age-inappropriate consonantal production errors and/or restricted consonantal inventories. More than half of the group had NWR scores below the 16th percentile. The correlations between individual measures of phonological accuracy and expressive language scores were strong. As with the TD children, these results were consistent with previous findings in that children with poor consonant accuracy and / or consonant inventories had limited or smaller vocabularies, indicating a relationship between the two domains for late talking toddlers (Carson et al., 2003; Paul & Jennings, 1992; Rescorla & Ratner, 1996).

While there was evidence of a relationship between phonology and the lexicon, it is important to note that the LTs in the current study were a heterogeneous group with varying phonological and language abilities. As noted in earlier chapters, the LT children could be assigned to differing subgroups based on their developmental and clinical profiles (e.g., Stackhouse & Wells, 1997). This diversity in profiles reflects variation in the relationship between phonology and expressive language across LTs such that there is varying commensuration and dissociation of developments within individuals. Previous studies have also reported variation in the phonological and/or lexical abilities of LTs at different stages of expressive vocabulary acquisition within this age range (e.g., Pharr et al., 2000; Stokes et al., 2013, Thal et al., 1995; Vihman et al., 2013).

At age 3;6 phonological accuracy and expressive language development were no longer commensurate in this group. In addition, more than half of the group scored below the 16th percentile on the NWR task. Results of statistical analyses showed a moderate strength of relationship between expressive language and PCC in picture naming, whereas a strong correlation with PCC in NWR remained. In terms of expressive language development, 40 out of 46 (87%) LTs who continued participation at age 3;6 showed resolved early expressive language delay (with or without speech delay). A majority of late talkers in previous studies (75%) have been reported to demonstrate resolution of their initial delay and achieve normal-range by age 3 years, regardless of differences in criteria or cut-off for expressive language used (Dale et al., 2003; Paul, 1993, 1996; Rice, Taylor, & Zubrick, 2008; Roos & Ellis Weismer, 2008). In terms of phonological development, about half of LTs were classified as Speech Delay (n=21, 48%). Various studies assessing short-term outcomes have shown that approximately half of LTs continued to demonstrate delays in phonological and/or expressive language skills when they were 3 years old (Paul, 1993; Paul, Spangle-Looney, & Dahm, 1991; Rescorla & Schwartz, 1990; Roberts et al., 1998). The LTs in the current cohort with a previous combined Speech and Language Delay had persisting speech delay, i.e., demonstrating a resolution of language skills prior to phonological skills. Those with a previous Language Delay only switched to a profile of Speech Delay only. Thus, the LTs in the present study were at a higher risk for delayed phonological rather than language development based on age 3;6 results. Similar variations in the phonological and expressive language abilities were observed, reinforcing the notion of differential patterns of commensuration and dissociation between the two domains of language in LTs.

At age 5;0, phonological accuracy and expressive language development were also not commensurate; reflecting a continued dissociation in the development of the two domains of language in LTs. While the group’s mean scores on the phonology test of PN fell within the borderline range of delay, LTs achieved scores that were within the average range according to normative data. Although the correlation between expressive language and PCC in picture naming continued to be insignificant, its correlation with PCC in NWR increased (consistently within the strong range). Similar to age 3;6, more than half of the LTs had NWR scores below the 16^{th} percentile.

It should be noted that children's expressive language was measured by the Expressive Language Index (ELI) of the CELFP2 at age 5;0 instead of the PLS4 used at age 2;0 and age 3;6. One of the reasons for this change was that children were achieving ceiling scores on the PLS4 which assessed global language. By introducing the CELFP2, children's grammatical ability was considered for the 5-year age group. The ELI score was derived from the combined scores of three subtests: Word Structure (WS; a sentence-completion task to assess children's knowledge of grammatical rules), Expressive Vocabulary (EV; ability to name pictures of objects, people, and actions, and Recalling Sentences (RS; which required children to listen to spoken sentences of increasing length and complexity and repeat verbatim what they had just heard). Therefore, given the strong grammatical correlates to language acquisition in children with language impairment with / without a history of late talking (Moyle et al., 2007; Moyle, Karasinski, Ellis Weismer, & Gorman, 2011; Paul, 1993; Rescorla, 2002), the finding that 94% of LTs within age appropriate range for this test was unexpected. Furthermore, all LTs who previously displayed delayed early receptive language scores showed resolution by age 5;0 years, although previous studies have reported receptive skill status to be a strong predictive factor of later school-age language outcomes (Ellis & Thal, 2008; Paul & Roth, 2011; Rescorla, 2011).

A plausible reason for the high percentages of resolution of early language delay in this study is the number of children whose parents have high levels of education; a factor similarly reported by previous studies to have an effect on language acquisition (Rescorla, 2011). It is assumed that children from such families receive rich linguistic stimulation at home thus reducing their risk for persistent difficulty (Hart & Risley, 1995; Reilly et al., 2010; Rescorla, 2011). Less than 5 LTs had received SLT intervention services so it is not likely that this factor has made an impact on the high percentage of resolution (Paul, 1996; Whitehurst & Fischel, 1994). Nevertheless, these percentages are based on the number of children who continued participation at age 3;6 and age 5;0. The profile of development of the 33 children from age 3;6 who did not participate at age 5;0 is unknown.

The diversity in children's profiles at this age was evidence of the continued dissociation between phonology and expressive language across development. Out of the LTs who continued participation at this age, 45% were categorized as having a Speech Delay and 48% with Typical Speech and Language. Thus, by age 5;0 the LTs in the present study continued to be at a higher risk for delayed phonological rather than language development.

Taken together, results across time points indicated a decreasing strength of relationship between expressive language and PCC in picture naming. On the other hand, the strength of the relationship between expressive language and PCC in NWR was inconsistent; (although within high levels) decreasing slightly at age 3;6 before increasing at age 5;0. Results were similar to previous findings of an early relationship between phonology and the lexicon in LT toddlers (e.g., Paul & Jennings, 1992; Rescorla & Ratner, 1996; Pharr et al., 2000). This finding supports the results from studies on older children with language impairment that have reported a relationship between PCC in NWR (as a measure of PSTM) and the sizes of children's vocabulary (Coady & Evans, 2008). Expressive language skills progressed into the normal range by age 3;6 in a majority of LTs. Those who did not achieve this milestone by then made further progress to achieve resolved expressive language delay by age 5;0. Nonetheless, about half of the group had delayed scores on the phonology test at each time point.

8.1.3 Across-group comparison of relationships over time

The patterns of relationship between individual measures of phonological accuracy and expressive language differed across development for both groups. Comparisons within and between groups were made. Figures 7.4 and 7.5 that depict the differences are reproduced here for ease of reference. Within the TD group the strength of relationship between expressive language and NWR across ages was consistently higher than for PN; however the relationship was more variable decreasing until age 3;6 and then increasing between 3;6 and 5;0 years. In contrast, the strength of the correlation between expressive language and PN consistently decreased. For the LT group, the strength of the relationships between expressive language and NWR was only higher than for PN at ages 3;6 and 5;0. The strength of correlation between expressive language and for PN consistently decreased, while the strength of the correlation between expressive language and NWR was stable at age 3;6 before increasing again at age 5;0 (within high levels).

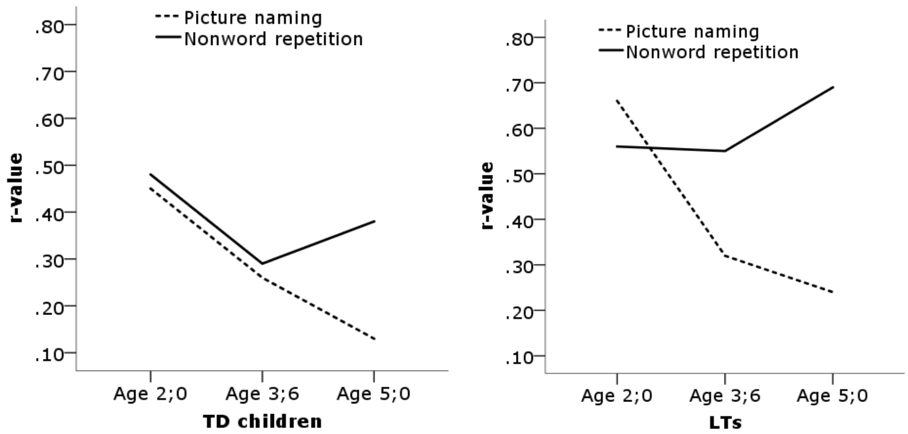

Figure 7.4. Correlations between measures of phonological accuracy and expressive language: Between TD and LT groups

When the correlations were compared between TD and LT groups, a stark difference was noted in the strength of correlations between expressive language and NWR at ages 3;6 and 5;0 (Figure 7.5 below). Beyond age two, the expressive language scores of both TD and LT groups showed a decreasing relationship with PN. Expressive language ability corresponded more highly with NWR accuracy in the LTs than TD children.

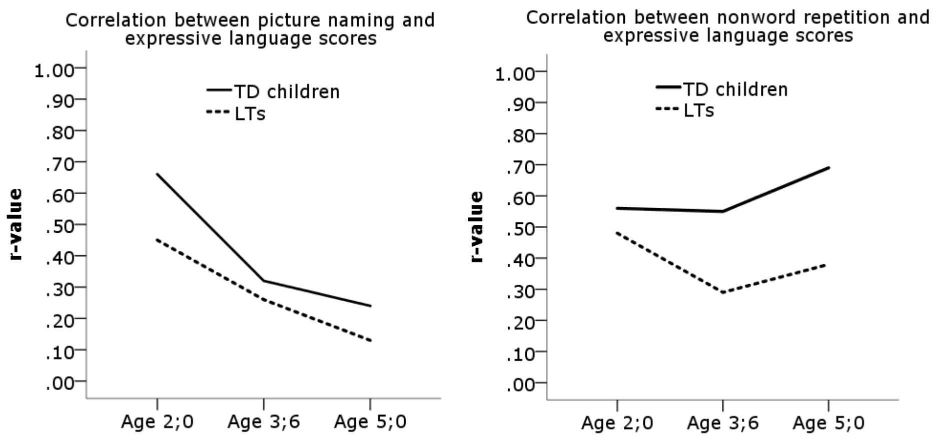

Figure 7.5. Correlations between individual measure of phonological accuracy and expressive language: Within TD and LT groups

In the LTs, dissociation between the development of phonology and expressive language was first observed at age 2;0. The expressive language skills of a majority of the LTs (87%) progressed into the normal range by age 3;6, and those who did not achieve this milestone by then, made further progress to achieve resolution to their early expressive language delay by age 5;0. However, about half of the group had delayed scores on the phonology test when assessed at ages 3;6 and 5;0. In the TD group, the emergence of children classed as Speech Delay was noted only at age 3;6. Nonetheless, both groups were similar in that there was an increase in the number of children categorised with Speech Delay by age 5;0. Amongst TD children and LTs whose profiles were tracked, a shift along a proposed continuum was observed where children's language impairment resolved prior to improved speech impairment.

In summary, the longitudinal results of the present study showed that a similar relationship between phonological accuracy (as measured by PN and NWR) and expressive language in LTs existed as in TD children at age 2;0. In general, increases in accuracy for PN and NWR corresponded with increases in expressive language scores for both groups. However, the relative strength of correlations between each measure of phonological accuracy and expressive language differed within groups across time. In particular, the continued strength of the relationship between NWR and expressive language for the LT group was notable. To further understand the nature of these different relationships, the next section discusses the interpretation of the results of the present study according to a psycholinguistic speech processing assessment of impairments.

8.2 Underlying impairments

The second research question asked whether underlying impairments in children's phonological systems contribute to early expressive language delay and persistence at outcomes. To arrive at the answer, the children's performance on phonological tasks was examined using the Stackhouse and Wells' (1997) psycholinguistic framework for assessment. Underlying deficits were inferred from observed accuracy of speech production during PN and NWR tasks, as well as standardised tests of phonological awareness (PA). With regard to the model, the focus of interest was on the phonological representation (Levels D and E) and the motor program/ming (J, G, H). The adapted version of the speech processing model is inserted here for ease of reference (Figure 9).

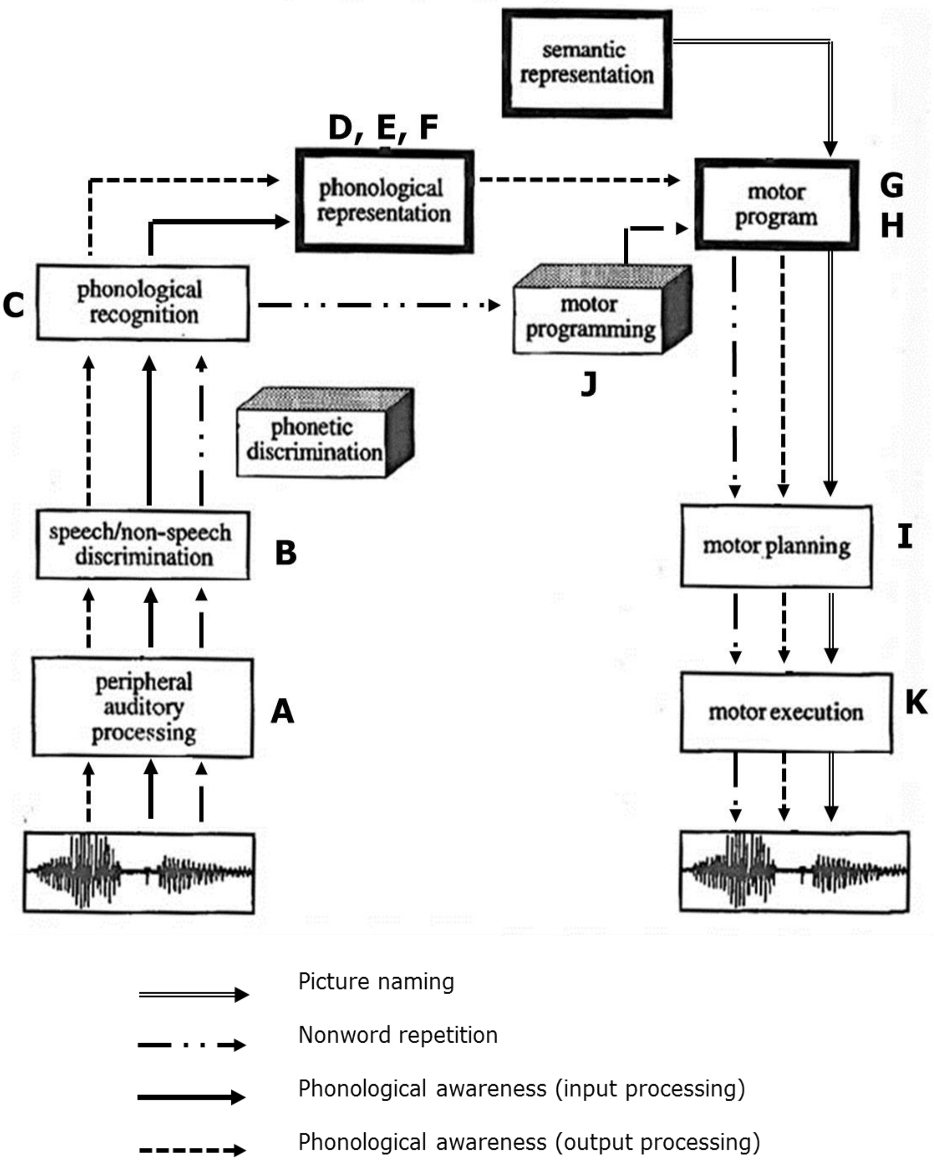

Figure 9. Processing routes for different speech processing tasks used. Reprinted and adapted with permission.

Tasks of PN and NWR were administered at all ages. As previously noted PN requires access to stored semantic representations, stored motor program (Level G) and activation of subsequent speech output processing levels (Levels I through K). In contrast, the TENR-R consists of target non-words that are low in word-likeness (Stokes & Klee, 2009). For these nonwords speech input would pass through phonological recognition (Level C), bypass access to lexical representation, towards generation of a new motor program (new word generation) where stored phonological units (biphones for example) were selected, and subsequently on to motor programs (Level J). At age 5;0 in addition to PN and NWR children engaged in a variety of phonological awareness tasks. With regard to the model, the phonological awareness tasks provided additional insights into children's phonological representation and motor programs at that age.

At all time-points children's peripheral auditory perception (Level A) was assessed using an otoacoustic emission (OAE) test. Parents were also asked if their children had been officially diagnosed with any hearing difficulty that could affect speech and language development within the last 18 months before the commencement of the session. No significant medical concerns were reported. The children in the current study were also not reported by parents or observed at sessions to have any structural abnormality to explain their phonological (in)accuracies or speech output (Level K).

8.2.1 Insights from TD children's speech processing profile

Tasks of PN assume accurate mappings of speech sound are accessed from well-segmented phonological representations (Stackhouse & Wells, 1997). Speech input is matched against an existing inventory in the phonological representation which then activates its semantic representations (for recognition) and/or motor programs (for naming). At age 2;0 TD children in this study demonstrated adequate stored semantic representations and motor programs that they could access to retrieve the labels for the presented pictures and name them with age-appropriate accuracy. This would explain the significant correlations between each measure of phonological accuracy and expressive language scores. NWR on the other hand bypasses lexical representations. In terms of influence, each phonological measure explained a moderate proportion of variance accounted for in TD children's expressive language scores at this age. The results at 2 years support the notion that TD children had adequate phonological representations and could efficiently access stored phonological units such as biphones and generate new motor programs to facilitate accurate repetition of nonwords. These findings are consistent with previous studies. For example, Stokes and colleagues (2013) reported a significant relationship between the NWR scores and diversity of the expressive lexicon in 113 monolingual, British English-speaking children between 25 and 29 months of age. They found that the lack of diversity in children's expressive lexicons was related to their poor ability to rapidly access phonologically representations with which to construct motor programs for both known and new / nonwords.

By age 3;6 TD children continued to perform at age-appropriate level for all tasks. They had accumulated adequate robust phonological representations to map onto semantic representations and stored motor programs that they could access for speech production as evidenced by the PN task. Likewise, motor programming was sufficient to perform adequately on NWR tasks. As children's lexicons became more advanced, however, neither measure of phonological accuracy significantly explained the proportion of variance accounted for in children's expressive language outcomes. Their ability to access and use stored motor programs for word retrieval and for the generation of new / nonwords were weakly related to their language scores. Nevertheless, although most TD children continued to manifest intact processing system at age 3;6, the development of language and phonology dissociated in some children in the form of a Speech Delay. Because the DEAP required children to access stored semantic representations motor programs for familiar words, this finding suggests that in these children immaturity of motor programs persisted and manifested as a speech difficulty despite adequate language acquisition (Vance et al., 2005). This points to a variation in the levels of maturity of TD children's underlying motor programs at this age.

At age 5;0 tasks to examine phonological representation more explicitly were added. Results of the Rhyme Awareness and Alliteration Awareness tasks revealed that

TD children have precise stored phonological representations at the segmental and rime levels. They were able to judge if words contain similar onsets, segment them at an intra-syllabic level, as well as demonstrate an understanding that rhyming words share endings that sound similar. When the measure of phonological awareness was added into the regression equation, it explained a high proportion of variance in TD children's expressive language outcomes.

In terms of their performance on PN and NWR tasks, TD children continued to obtain age-appropriate scaled scores. Increased accuracy for PN indicated increased precision in stored motor programs (Level G); however that was no longer related to their expressive language abilities. Within the TD group variations reflected underlying differences for some children. For instance, given that the DEAP contains familiar stimulus items, the presence of Speech Delay but intact expressive language could be interpreted to reflect a persisting immaturity of motor programs rather than scarce phonological representations. This is because children with specific speech delays have been found to not necessarily have impoverished phonological representations (Nathan et al., 1998). It may be that despite experience with adult interaction and exposure to adult models of accurate pronunciations, they persisted at the stage where they attempted to reproduce features of words stored in their motor program within the constraints of immature components of output processing (Stackhouse and Wells, 1997). If the process of phonological development continues until children are about 9 years old (Shriberg et al., 2010) fully specified and robust motor programs cannot be expected in these children aged 5;0. Inaccurate motor programs for words learned at a point in development when speech processing skills were inefficient can change with a maturation of speech-processing skills (Vance et al., 2005).

TD children's performance on the NWR task improved with maturation and continued to be significantly related to their expressive language abilities. NWR made a significant unique moderate contribution to the proportion of variance accounted for in expressive language outcomes. This reflected their efficient use of the motor programming (Level J) facility in their speech processing system. A number of children at age 5;0 were observed to repeat a nonword with a word substitute eg. [mæd] for /mad/, [dɒlfɪn] for /dafi/, [boʊt] for /boʊk/ (although no fronting errors were noted during the DEAP test and conversations) usually with a rising intonation at the end accompanied by a questioning look towards the examiner as if unsure if they had heard correctly. This usually occurred with children who had good language skills (the administration of this test followed that of the CELFP2 and so the examiner had a good idea of children's language skills by then). Children were playfully reminded that the target words may sound like real words and that they were to simply *"say exactly what the lady says"* and not to change the aliens' names or *"they won't know you were calling them".* If these children were simply seeking clarification to confirm that they had not misheard, this addition to the instructions appeared to have clarified initial 'doubt' and reinforced the behavioural requirements of the test. Alternatively, their reactions could have been outward behavioural manifestations of processes called redintegration or lexicalization. Redintegration refers to a process where children are able to use their existing knowledge about the syllables and/or phonological segments of words from the ambient language, when the memory trace for a signal or phonological representation has dissipated, as a strategy to recreate a new or nonword or facilitate accuracy of targets to be repeated (Gathercole, Frankish, Pickering, & Peaker, 1999; Ritchie, Tolan, & Tehan, 2015; Stokes, Wong, Fletcher, & Leonard, 2006). Lexicalisation involves the production of a similar sounding real word in place of a nonword and had been attributed to either input or output difficulties. More than an average frequency of occurrence in children had been hypothesized to reflect a deficit in auditory lexical processing based on observation in a few case studies (Stackhouse & Wells, 1997). These children were able to use existing semantic representations and motor programs to retrieve a similar-sounding word as a response. TD children's ability to use motor programming to reconstruct and repeat new / nonwords accurately was related to their high expressive language scores. Their phonological awareness scores showed that in addition to use, they were also able to manipulate existing motor programs and phonological units at the syllabic and phonemic levels (Level H). They were proficient in verbally segmenting speech input into their individual phonemes, as well as in recognizing and verbally isolating onsets from rimes. The significant, strong and positive correlations between the composite scores from the subtests of phonological awareness and EL for TD children indicated that their ability to manipulate word structure was also highly related to their language ability at age 5;0, with a bi-directional effect or mutual influence between both measures at this age.

Taken together, longitudinal results suggest that with maturation TD children as a group further acquired detailed or adult-like representations as manifested in the increased accuracy of speech production for word retrieval and new/nonword generation. They were also capable of detecting the properties of their ambient language and of manipulating its phonological units to create new or more accurate motor programs. These factors contributed to their continued expressive language development.

8.2.2 Insights from LTs' speech processing profile

At age 2;0 the LTs' as a group performed below age expectations across tasks. This indicated a generally weak processing system with limited lexical representations. As previously stated, phonological representations are closely connected to the semantic representations and motor program for different types of speech output (Stackhouse & Wells, 1997). Phonological accuracy for PN was the only measure that significantly and strongly explained the proportion of variance in LTs' expressive language scores. The strong effect of PCC in picture naming, in contrast to the insignificant effect by PCC in NWR on LTs' expressive language scores, reinforced the notion that their speech production was dependent on the availability of stored phonological representations. Adequate underlying phonological representations must first be established in order for LTs to create strong mappings of the phonological forms of words to their meanings (semantic representation) and stored motor programs.

Unlike the Stokes and Klee (2009b) study, the NWR (TENR-R) scores did not contribute significantly to the variance in LTs' expressive language scores at age 2;0. One plausible explanation considered was that in the present study the data points for a third of the LTs who had zero scores for the NWR test were included in the regression analyses, unlike in the Stokes and Klee (2009b) study. Therefore, in order to test if the different findings could possibly be due to differences in the sample included into the analyses and the floor effects for NWR, data was reanalysed excluding the zero scores. A similar non-significant contribution was found, confirming the first finding.

The presence of subgroups of LTs with varying profiles or at different developmental phases suggested differential deficits in motor programs. LTs who were transitioning between the pre-lexical and whole word phase (non-verbal stage of communication or with very few meaningful words) would not have adequate phonological representations in order to form strong mappings between semantic representations and motor programs needed for labeling and/or imitating the names of familiar pictures. Vice versa, children who did not recognize a picture or did not have the word in their vocabulary were not able to retrieve the phonological information about the item. They were also less efficient at utilizing the phonological representation and motor programming components to generate new motor programs to repeat unfamiliar real and nonwords respectively. LTs who were at the whole word phase with relatively more words in their vocabularies were either able to name them all independently or required verbal models to do so, both with varying levels of spontaneous and imitation accuracy (complete or partial). These LTs would have access to stored motor programs via semantic representations to name familiar pictures spontaneously or via phonological representations to imitate real words. They were also more efficient at utilizing the phonological representation and motor programming facility to generate new motor programs to repeat unfamiliar real and nonwords respectively. The LTs who demonstrated average performance on the PLS4 could be considered to be entering the systematic simplification phase where children begin to simplify adult phonological forms with some consistency (Stackhouse & Wells, 1997). These LTs would relatively be more able to access stored semantic representations and motor programs to name pictures with age-appropriate phonological accuracy.

At age 3;6 LTs continued to make gains in vocabulary and acquired adequate and relatively more specified phonological representations to enable them to name familiar pictures and repeat nonwords with increased (although varying) accuracies. In terms of influence, the proportion of variance in LT's expressive language scores was solely explained by PCC in NWR. This was a complete switch in predominance and contribution from age 2;0. This observation reinforced previous suggestion that robust and precise phonological representations were important for laying the foundation for lexical or language acquisition and accuracy of production. Over the 18-month interval, LTs had access to more varied phonological units (for example biphones) for the online creation of new representations when acquiring new words. Ability to access motor programming for the generation of new / nonwords continued to be highly related to their expressive language ability. In fact, the measure of PCC in NWR accounted for a moderate proportion of the variance in LTs' expressive language scores replacing the measure of PCC in picture naming as sole unique contributor. This finding was consistent with previous hypothesis that phonological representations contain considerable detail with increased vocabulary size and sensitivity to phonemes (Coady & Aslin, 2004).

A larger percentage of LTs (n=18, 39%) fell into the category Speech Delay (with or without Language Delay) at age 3;6. This finding suggested that despite adequate language, immaturity of and inaccurate motor programs persisted in these LTs. While children in the Speech Delay subgroup displayed a delayed process of maturation of motor programs, children with Speech and Language Delay also manifested poor mapping of phonological forms to both semantic and grammatical representations (Stackhouse and Wells, 1997).

Finally, at age 5;0 an impressive 94% of LTs achieved scores within the average range on measures of expressive language and speech processing. In terms of input processing, results of the Rhyme Awareness and Alliteration Awareness subtests revealed that LTs have well-specified stored phonological representations at the segmental and rime levels. They were able to judge if words contain similar onsets, segment them at an intra-syllabic level, as well as demonstrate understanding that rhyming words share endings that sound similar. In terms of output processing, their ability to use motor programs for word generation on the PN task was no longer related to their expressive language abilities. Nonetheless, the consistent finding of more than half of LTs with poor phonological accuracy at each time point indicated a higher risk among LTs to have a persisting immaturity of motor programs (Level G) despite experience with adult interaction and exposure to adult models of accurate pronunciations. Persisting immature motor programs had restricted their ability to accurately reproduce features of familiar words stored in their motor programs (Stackhouse and Wells, 1997). Half of the LT group displayed poor performance on the NWR task reflecting continued inefficient use of the motor programming component (Level J) of their speech processing system to create new / nonwords.

In terms of their phonological awareness, LTs demonstrated that they were able to manipulate existing motor programs and phonological units at the syllabic and phonemic levels (Level D). That is, they were able to recognize and verbally segment speech input into their individual phonemes and isolate onsets from rimes. The significant, strong and positive correlations between the composite scores from the subtests of phonological awareness and expressive language for LTs indicated that their ability to manipulate word structure was highly related to their language ability at age 5;0. The measure of PCC in NWR and phonological awareness accounted for a moderate proportion of the variance in LTs' expressive language scores at age 5;0.

Taken together, the results suggested that with an increase in experience and expressive language, LTs as a group acquired relatively detailed representations and were able to detect and manipulate properties of their ambient language. However, their expressive language ability continued to be dependent on their phonological awareness and efficiency in activating motor programming to generate new / nonwords.

8.2.3 Across-group comparisons of underlying systems over time

TD toddlers entered the study endowed with adequate stored lexical representations. Their higher expressive language ability was significantly related to their ability to efficiently use existing motor programs to retrieve known words (for PN), as well as their ability to access stored phonological units in motor programming to imitate or repeat nonwords. That is, when TD children hear or learn a word for the first time, they were efficient at processing the sound-based information these words contain and at accessing and assembling stored phonological units into new motor programs for immediate imitation. In fact, the correlation between their expressive language skills and NWR across time point was the strongest at this age, as shown in Figure 7.5.

In contrast, LTs entered the study with a vulnerable system overall. Their poorer expressive language scores were significantly associated with their ability to retrieve known words for PN. It was the correlation between their expressive language skills and PCC in picture naming at this age that was the strongest across time points and independently impacting expressive language. Their expressive language skills relied strongly on their ability to access and retrieve from existing stored motor programs, which in their case was limited due to a deficit in phonological representations. Scarce phonological representations restrict the establishment of strong mappings of the phonological forms of words to their semantic representations as well as motor program required for retrieval of known words and/or immediate imitation of real words. Yet, LTs were also inefficient at accessing stored phonological units to construct new motor programs for immediate imitation or generation of new / non words. This brings the discussion to the role played by phonological recognition; the level where children process and distinguish between speech input that follows the phonological patterns (probabilistic properties) of the ambient language (and are processed) from those that do not. The ability to recognise statistical cues such as probabilistic properties in speech input have been observed in typically developing infants as young as 9 months (Saffran & Graf Estes, 2006; Saffran & Wilson, 2003; Storkel & Morisette, 2002) or infants in the Prelexical Phase of the Developmental Phase Model (Stackhouse & Wells, 1997). Studies comparing TD children and LTs have suggested differences in how they use statistical cues as a strategy to help them associate the phonological form of words to their meanings and learn new words. For example, unlike TD peers, the lack of sensitivity to the regularities in the phonological system in late talking toddlers inhibited their ability to filter in and store the phonological representations needed to learn words (MacRoy-Higgins et al., 2013). However, also as previously mentioned, Stokes (2014) concluded that while LTs utilise similar abstraction strategy as younger TD children, the higher use of dense words for expressive production (despite comparable combination of stored sparse and dense words) were due to insufficient robust phonological representations to support speech production. This study, as Stokes stated, was based on parent report rather than direct testing of participants' receptive or expressive vocabularies. Given the varied profiles amongst the LTs in the present cohort (those with zero scores for PN and NWR) both accounts are relevant. According to the current framework, variation in profiles may be a result of varying efficiency at activating phonological recognition. It may be that speech input that conform to the phonological patterns of the ambient language were either incorrectly filtered out or inefficiently segmented or parsed, thus affecting their mappings and eventually output. Longitudinal examination of pre-lexical LTs' ability to discriminate between phonologically legal from illegal nonwords (Stackhouse & Wells, 1997) could be trialled in future research.

Subsequently, with maturation and development, both groups continue to make gains in expressive language at the ages of 3;6 and 5;0 years. As children's vocabulary sizes increase it facilitated their ability to make further generalizations about the phonological structure of the language which contributed to more robust underlying phonological representations that aid phonological processing. Increased accuracy in speech production, although at different rates, was evidence of the more refined and specified phonological representations and increased accuracy of stored motor programs. However it is important to note that subgroups with different phonological skills in relation to expressive language abilities were present within TD and LT groups, with an increased percentage of those with Speech Delay by age 5;0. This indicated persisting immature motor programs for these children. Nonetheless, it must be acknowledged at this point that the Stackhouse and Well's (1997) model offers one way of interpreting the results. In keeping with the essence of this approach, results should be interpreted within a larger context in which young children develop, incorporating other possible interpretations and findings from various fields of study. For example, residual speech delay (Shriberg, 2010) implicating peripheral levels of output processing (Stackhouse & Wells, 1997) expected in young children at this age could also be implicated. Alternatively, it is also possible that children's (whether TD or LTs) low phonological accuracy is the "consequence of less robustly specified perceptual targets for speech production" (Munson, Baylis, Krause, & Yim, 2010, p. 381). Given research by Dodd and McIntosh (2010), yet another possible interpretation for the poor phonological skills by age 5;0 years is that the children have difficulties with abstract rules from the ambient language.

As they continued to encounter new words with development, TD children's and LTs' expressive language skills no longer depended on their ability to access stored motor programs to retrieve known words. This was in contrast to the continued reliance on their ability to access motor programming and construct new motor programs from selected phonological units in real time to generate new / nonwords (Figure 7.5). In fact in the LTs the reliance on this process was the highest at age 5;0. That is, LTs' expressive language ability was highly associated with their ability to rapidly activate motor programming and phonologically encode new / nonwords accurately. Another possible explanation for the differences is in how TD children and LTs use the process of redintegration raised previously. Unlike their TD peers, children with poor language ability such as LTs may be less able to rapidly recruit phonological units of known words to facilitate accurate repetition of new / nonwords.

Both groups' performances on the subtests of phonological awareness at age 5;0 further confirmed the presence of detail in their phonological representations. Correlations between the composite scores from the subtests of phonological awareness and expressive language for both TD children and LTs in this cohort were significant, strong and positive, indicating that children's ability to detect and manipulate phonological units at the syllabic and phonemic levels on tasks that probe their output processing skills was also related to their expressive language skills at this age. In terms of specific subtests of phonological awareness, LTs as a group were found to perform comparably to their TD peers on the subtest of Syllable Segment. Based on this results, LTs were comparable to their TD peers at using statistical learning for the detection of syllable boundaries and using existing knowledge of phonotactic constraints and syllable patterns in words as a cue to verbally segment unfamiliar words into syllables by age 5;0. Further investigation of the subtest of Syllable Segment may reveal lexical (density and frequency) and sub-lexical (phonotactic) effects that could have facilitated the average performance in LTs (Storkel, 2004).

LT group's performances on the other subtests of phonological awareness were significantly different compared to their TD peers (Table 7.5). LTs had significantly poorer concepts of rhymes and at detecting differences between known words at the level of rimes at the input processing level. They were also less proficient at manipulating phonological units at the syllabic and phonemic levels on tasks that probe their output processing skills. The TD children were significantly more sensitive to or efficient at detecting and manipulating properties of their ambient language and at using them for speech production.

8.2.4.1 Memory and/or phonological processing

Thus far children's performance on the test of NWR has been discussed in the context of their ability to activate the motor programming component of the speech processing model. As discussed previously, the fact that NWR tasks tap many different underlying processes is the subject of much on-going debate (Coady & Evans, 2008; Jones, 2016). One of the questions often asked is if NWR measures phonological short-term memory (PSTM) separate from other phonological processes as have been extensively studied and proposed by Gathercole and colleagues (Baddeley, 2003; Gathercole & Baddeley, 1990a; Gathercole et al., 1994). Among those who disagreed with this notion contended that the factor underlying the relationship between NWR and word learning is phonological processing (Dollaghan et al. 1995; Leitao et al. 1997; Snowling et al. 1991). According to others like Bowey (1996, 1997, 2001) and Metsala

(1999), phonological memory and awareness/sensitivity are not separate because they are both surface manifestations of underlying phonological processing abilities. However, their criticism pertained to the notion of a causal influence of PSTM on vocabulary acquisition. This is based on the findings of their own research where they argued that NWR is instead influenced by vocabulary development and improved sensitivity to phonological structures (Bowey, 1996; 2001; Metsala, 1999). While they do not negate the involvement of PSTM, they posited that the mechanism underlying the relationship between NWR and vocabulary is phonological processing. In the speech processing model of Stackhouse and Wells the role of PSTM is not directly determined as it is considered to be involved in a range of tasks across different levels of processing (Vance et al., 2005; Stackhouse & Wells, 1997).

In fact, in a large-scale longitudinal study by Gathercole and colleagues (2005) no evidence of persistent PSTM deficit on language development in children was found. This study involved 4- and 5-year-old children who were tested on PSTM and non-verbal intelligence and assigned to two groups (those screened with PSTM deficits and those who did not). These children were then retested at age 8 on measures of PSTM (digit span and NWR), language and vocabulary. The study found that children with persistent PSTM deficits showed comparable language and vocabulary scores to a control group, whereas those without persistent PSTM deficits displayed not only poorer oral language and vocabulary scores compared to control group, but also lower verbal IQ than peers. Therefore, it may be that the children had an initial deficit in general verbal processing rather than PSTM which impacted vocabulary and language development. Melby-Larv°ag and colleagues (2012) reported the results of their 3-year longitudinal study in which they measured children's (n=219) performances on vocabulary and nonword repetition at yearly intervals when the children were between 4 and 7 years old. They found each measure to be stable over time with children's later performance on a measure being predicted by an earlier one. They concluded that their results were inconsistent with the claim that PSTM (as measured by NWR) was a mechanism that underlies vocabulary and language development.

Turning to the current study, the two measures of memory and/or processing used were the TENR-R and PIPA. Although they were not specially designed to differentiate between phonological memory and phonological sensitivity, an inference could be made from a consideration of the behavioural requirements and results of children's performances on these tests. If we consider the TENR-R's design, it consists of about 90% early developing phonemes, no consonant clusters, and nonwords low in word-likeness. These factors reduce the effects of articulation and access to lexical representations on accuracy (Dollaghan & Campbell, 1998; Gathercole, 2006; Stoel-Gammon, 2011). Children were required to attend to auditory stimuli of unfamiliar words with increasing number of syllables to phonemically encode and create temporary representations to assemble a response. If new phonological knowledge requires long enough storage for the representation of a word to be formed, impairment in PSTM would restrict children's ability to process the phonological details in words heard thus impacting the accuracy or complete formation of this representation and new word learning. Both the PSTM and the ability to phonologically process speech input were involved. As such, the TENR-R can be considered a measure of PSTM and phonological sensitivity (components of phonological processing). The PIPA, on the other hand, was used as a measure of phonological awareness consisting of simple target words which were mostly associated with coloured pictures and presented verbally by the examiner. While the effects of lexical and phonotactic properties of the stimuli are unknown, the PIPA cannot be considered to significantly tap children's memory.

Based on correlational analysis, the PSTM was associated with the expressive language scores of both TD and LT groups across development as measured by the TENR-R in the current study. This would be consistent with prior findings of a significant relationship between NWR and vocabulary (Gathercole & Baddeley, 1990; MacRoy-Higgins et al., 2013; Rescorla, 2009; Stokes, 2013; Stokes et al., 2012; Whitehouse et al., 2011). However, in terms of its effect on expressive language, the findings were different for both groups. The current study found a significant effect of the TENR-R in TD children at age 2;0, but not when they were older, suggesting that while PSTM had a role in the early stages of typical expressive vocabulary acquisition, its effect was less significant at later stages of language development (Gupta & Tisdale, 2009; Chiat & Roy, 2013). In the LT group, the lack of an early effect of the TENR-R but significant effect at ages 3;6 and 5;0 would suggest an increased reliance on PSTM for storage and creation of lexical representations needed for vocabulary growth. A caveat associated with these findings relates to the inclusion of the PIPA into the regression equation at age 5;0. In the TD group, the PIPA replaced the TENR-R in accounting for the variance in their expressive language scores. In the LTs, unique contribution to the proportion of variance accounted for was shared by both the TENR-R and PIPA. These findings suggested that phonological processing ability was the mediating factor in the expressive language development of the LTs in the current cohort; corroborating previous findings of persistent processing deficits in LTs throughout development (Rescorla, 2013).

Underlying difficulties with memory and linguistic processing have also been implicated in studies examining sentence repetition accuracy of children with language impairment including various other factors such as impaired grammatical and syntactic knowledge and representations, attention, temporal processing or a combination of them (Archibald & Joanisse, 2009; Conti-Ramsden, Botting, Simkin, & Knox, 2001; Montgomery et al., 2010; Stackhouse & Wells, 1997; Stokes et al., 2006). Repeating sentences requires children to deploy statistical strategies for identifying regularities in sentences (Boyle, Lindell, & Kidd, 2013). In the current study, despite the high percentage of LTs with resolved language impairment at age 5;0 group expressive language performance was found to be significantly different from that of their TD peers. Therefore, their sentence repetition skills are discussed next.

8.2.4.2 Recalling sentences

The expressive language index (ELI) was derived from the scores of three subtests; one of which was the subtest of Recalling Sentences. The ability to repeat sentences has been examined and proposed to be a useful clinical marker of SLI with high levels of overall accuracy (88%), sensitivity (90%) and specificity (85%) in older

English-speaking as well as non-English-speaking subjects (Conti-Ramsden et al., 2001; Leclercq, Quemart, Magis, & Maillart, 2014; Stokes et al., 2006). A study on LTs that had identified significant group differences on similar measures was that by Moyle and others (Moyle et al., 2007). They reported group outcomes between 30 LTs first identified on the MCDI at age 2 (scoring at or below the 10^{th} percentile) with TD children matched on gender, age, nonverbal cognitive ability, and SES. Both groups were tested on a standardised test of language measuring oral vocabulary, grammar, and sentence repetition. LTs were reported to perform significantly poorer than TD group especially in sentence repetition (Cohen's d scores of .97, 1.46, and 1.52, respectively).

Significant correlations between children's accuracy on sentence repetition and on NWR have been reported (Bishop & Donlan, 1996; Conti-Ramsden et al., 2001). In the current study, these two measures were moderately and strongly correlated in TD and LT groups, $r(1,79)=.42$, $p<.001$, and $r(1,29)=.64$, $p<.001$, respectively. Both of these measures were in turn significantly correlated to the groups' Expressive Language Index (Tables 7.4 and 7.5). However, although LTs' ability to recall sentences accurately was significantly different from their TD peers, $F(1,110)=27.97$, $p<.001$, regression analyses showed that the proportion of variance in groups' ELI was explained by different measures. In LTs' it was moderately accounted for by sentence repetition, $\beta=.43$, $p<.001$, whereas in TD children it was explained by the subtest of expressive vocabulary, $\beta=.47$, $p<.001$. These results indicated that compared to their TD peers, LTs' expressive language abilities depended more significantly on their ability to listen to words and sentences of increasing length and complexity and repeat verbatim what they had just heard. This finding reinforced the notion of a persistent processing difficulty in LTs. In a study involving 216 children assessed on measures of vocabulary knowledge, grammar and sentence repetition at age 4 and again at age 6 years, Klem et al. (2015) found that sentence repetition was not a unique predictor of later language development. It was found to correlate significantly with the other language variables indicating that it measures various levels of language processing skills.

8.3 Summary

In summary, this chapter has discussed early relationships between phonology and the lexicon, their trajectories and influence on children's expressive language abilities over time, as well as an exploration of possible deficits in underlying processes using a psycholinguistic framework for assessment in TD and LT children between 2:0 and 5;0 years old. The following themes have emerged from the present study:

First, LT toddlers were not a homogenous group with far more subgroups than TD toddlers when profiled based on their phonological and language performances on the respective standardised tests. By 5 years old, children who started out as LTs at age 2;0 had a higher risk of having persistent speech sound errors than a persistent language impairment.

Second, phonological and lexical developments were associated in LT and TD groups most notably during the point in development when first words emerge. However, each group's expressive language abilities was affected by different measures of phonological accuracy, with the important role of motor programming and motor program (and their relation to phonological representation) at the early stages of lexical development being highly emphasized.

Third, beyond age 2;0 and up to school entry observed improvements in both groups' performances were considered similar manifestations of increasing (but different) ability to establish strong mappings of the phonological representations of words to their semantic representation and motor programs. With maturation and development, the factors that evidently set the groups apart was their continued reliance on an effective motor programming component (and its relation to motor programs) for generating new / nonwords, as well as their ability to detect and manipulate the word structures of speech input.

8.4 Limitations of the current study

Several limitations of the current study must be acknowledged. First, the level of parental education is skewed towards higher levels of achievement. Compared to the general population, a considerably higher proportion of parents had university degrees and few with no secondary qualification. Parents' high level of education tend to be associated with high level of family SES, and these factors were significantly related to children's higher expressive vocabulary scores and better language outcomes (Hart & Risley, 1995). Thus, similar to other research on LTs involving predominantly middle to upper middle-class sample, the high percentage of resolution amongst the LTs in the current cohort could be assumed to be associated with optimal parent input and interactional styles that facilitated language enrichment (Rescorla, 2011; Rescorla, 2013). This study is also based on children from English-speaking family backgrounds and may not reflect the developmental patterns of young children who are exposed to additional languages and languages with different phonological systems. These factors may limit the generalizability of findings to a more diverse population.

Second, the lack of significant effect of nonword repetition accuracy on TD children's expressive language observed at age 3;6 could be attributed to the use of a global test of language which perhaps did not adequately tax specific language domains such as morpho-syntactic skills, given the strong grammatical correlates to language acquisition at ages 3 and 4 (Bishop, Adams, & Norbury, 2006; Rescorla, Dahlsgaard, et al., 2000; Rice et al., 2008). Administration of the test of phonological awareness at age 3;6 would allow children's input and output processing skills to be tracked and longitudinally compared, and may reveal similar correlational and regression results as in age 5;0.

Third, although the use of PCC served the study well as an index to quantify children's severity of production and judge the general level of their phonological performance, the limitation of using PCC as the only measure of phonology should be addressed. In the calculation of PCC all consonant errors are equally weighted, hence, information regarding the differences between error patterns was not captured. In particular, PCC does not distinguish between atypical and age-appropriate errors or deletions and substitutions. For example, the production of "bam" for "spam" and "am" for "spam" both yield a score of two out of four possible consonants correct, although if evidenced in the sample of a 4-year old, the former error would be considered delayed while the latter atypical. Given that atypical phonology has been identified in late talkers (see Williams & Elbert, 2003), qualitative indices such as phonological pattern analysis should be used in addition to the PCC.

8.5 Strengths of the current study

The prospective longitudinal nature of the current study allowed for the developmental trajectories of phonology and the lexicon to be tracked over three time-points. It also allowed for efficient analysis of their relationships, as well as identification of potential underlying mechanisms affecting them. First, it adds to current understanding of the relationship between phonological and lexical / language development in young children, and how this relationship changed over time. The identification of various profiles and changes in subgroup membership extend current understanding of the characteristics of late talkers and how they progress with maturation. Such information is needed in order to improve current methods of early identification and assessment of needs for intervention services. For example, using the current late-talking criteria only four children from the full sample who continued participation at age 5;0 were identified with persisting expressive language impairment. However, about half were identified with delayed phonological development requiring further monitoring at the minimum. The longitudinal nature of the study also adds to current understanding of the processes underpinning impairments and their interactions with development, which allows for more specific targets to be set for intervention.

Second, unlike studies on young children that rely solely on parent report, the current study included standardised tests selected for their psychometric properties, and which were commonly used in clinical practice. The use of standardized assessments with elicited production tasks allowed for children's linguistic systems to be optimally tapped compared to language sampling. Furthermore, the flexibility of administration (e.g., no strict sequence to be followed) and play-based nature of the tests, as well as clinical experience of the Research Assistants (all trained Speech and Language

Therapists), demonstrated that optimal participation from young children could be obtained. The use of these tests allows efficient transfer or application of results into clinical or classroom practice. The phonological measures in this study account for a good portion of variance in predicting LTs' concurrent expressive language scores; about 47% at age 2;0, 28% at age 3;6, and 48% at age 5;0 which increased to 66% when the measure of phonological awareness was included.

Finally, the high level of commitment to the study by parents contributed to an encouraging percentage of participation which helped to keep attrition low and sample sizes satisfactory.

8.6 Implications for clinical practice

This study has reported evidence to indicate that screening and intervention services may be warranted for late-talking children whose vocabulary sizes are at or below the 10th percentile according to the CDI or not combining words by age two according to parents' report. Results indicated that these children were at a higher risk for delay in phonological development compared to language impairment. For clinicians, results justify the administration of a measure of phonological accuracy (spontaneous naming and/or imitation) to supplement parent report of vocabulary. Clinical assessment of children's late language emergence should include analysis of phonological skills, and that change in these skills should be monitored (Paul & Jennings, 1992).

At the minimum, therapy / intervention service could be provided in terms of monitoring at regular intervals, and to include collaborative services to families as well as early learning centres. Like other studies of late talkers, the current study comprised a predominantly middle to upper middle-class sample and environmental and maternal education were among the factors reported to contribute to the resolution of language delay amongst late talkers, and assumed to similarly contribute to the high percentage of resolution in the current cohort (Rescorla, 2011). We also recall that the different studies on late talkers had hypothesised an interdependence and interplay between phonology, volubility, communicative interaction, and vocabulary size (Mirak & Rescorla, 1998; Paul & Jennings, 1992; Rescorla & Ratner, 1996, Pharr et al., 2000, Vihman et al., 2013).

Therapy should be informed by data obtained from children's current linguistic statuses or profiles, in line with the key theme of the psycholinguistic framework (Stackhouse & Wells, 2001). For example, the differing patterns of phonological and language difficulty suggest that children who are nonverbal or with few meaningful words may benefit from therapy targeting at building their linguistic experiences in order to enrich their phonological representations. Therefore, it may be that these children would benefit from more frequent exposures and input to establish and reconfigure existing inaccurate motor programs during interactions. Word learning studies involving preschool and school-age children with language impairment had reported evidence for the influence of input frequency on the emergent vocabulary and vocabulary development in general. For example, in a recent study on pre-schoolers' speed of learning four new words presented during interactive play, children with language impairment were found to require more frequent exposures in order to match the performance of age peers (Gray, 2004). Therefore, more exposures to develop robust phonological representations and establish strong mappings of the phonological forms of words to their meanings (semantic representations), as well as motor program, would benefit some LTs. The first words in children's spontaneous production are those that they have previously learned to imitate (Olswang et al., 1998). LTs with emerging lexicons may benefit from imitative activities to activate their motor programming facility (Stokes et al., 2013). The ability to imitate emerges very early in typical development and often during interactions with a responsive caregiver. Parents could be guided on the use of strategies to systematically elicit imitation (Olswang & Bain, 1996) embedded during play with highly motivating items, book sharing and/or daily routines.

Close examination of stimulus items on the standardised tests that children have difficulty with (in terms of phonotactic probability and neighbourhood density) could inform clinicians on the selection of words to be targeted for therapy (Stackhouse & Wells, 2001; Stokes et al., 2013; Storkel, Maekawa, & Hoover, 2010). For example, children with Speech Delay may benefit from target words that comprise uncommon sound sequences and sparse neighbourhoods may facilitate triggering with phonological delays (Storkel et al., 2010). The need to incorporate phonological awareness in the scope of intervention for pre-schoolers with language impairment is reinforced by this study. There is a need to provide increased exposure to phonological materials in order to facilitate increased precision of phonological representation and continued activation of motor programming for the creation and storage of accurate motor programs.

8.7 Implications for future research

Current evidence shows that 70-80% of LTs will outgrow their language delays especially if it only involves an expressive delay (Ellis & Thal, 2008). An estimated 20-30% will continue to have persistent language difficulties, even into their adolescence (Dale et al., 2003; Rescorla, 2011). That being said, studies differ in how they identified late talking and language impairment, as well as in the outcome language measures they used. Based on the current data set resolution of early language delays for 87% of LTs at age 3;6 and 94% at age 5;0 were found. The high percentage at age 5;0 included those with an earlier delay in receptive language. While few children with persisting language impairment were identified from the current cohort, a novel finding was the trend of increased emergence of children with persistent difficulty with phonological accuracy with or without co-occurring language impairment at age 3;6 and age 5;0 in both TD and LT groups; the proportion being higher in the latter group. Similarly, a higher proportion of LTs than TD children at age 5;0 also had persistent difficulty with phonological accuracy for repeating nonwords. Based on the results of this study further research is needed to determine the utility of using children's early speech processing abilities as co-indicators of late talking in addition to vocabulary size.

More fine-grained analyses of the data are indicated due to the limitations discussed previously with using the PCC as the only measure of children's phonology, and in light of the extant literature on atypical phonology in 2-year-olds, and the impact of atypical phonology on children's longer-term outcomes (e.g., Preston et al., 2013). In particular, the finding that "quantitative data was not a reliable predictive indicator of speech disorder, qualitative analysis of error types was predictive, with children who made many atypical errors at 2 years being diagnosed as phonologically disordered at 3 years" (p. 460, McIntosh & Dodd, 2008), and that "qualitative, rather than quantitative, measures of phonology are better predictors of outcome" (p. 468). It is possible that different developmental paths could be identified by using both quantitative and qualitative indices of phonology.

Although the current study involved a sufficiently large sample at each time-point, a larger sample at age 5;0 would allow for establishing profile groups with sufficient cell sizes to further examine and compare the interplay of phonological and lexical development between subgroups. Such profiling would be useful for identifying and comparing potential weaknesses and the extent of deficits and influence of underlying processes. Longer term research with larger sample sizes could clarify current approaches with regards to, among others: (1) improving the identification and characterisation of LTs, (2) do different profiles result in different outcomes and if they do, what underlying impairments were associated with each, (3) which profile would have priority for intervention and what would be an efficient intervention program. For example, from the current data set further examination is indicated of the phonological data from children in the TD group categorized as having speech delay at age 5;0 in spite of TD profiles at 2;0 and 3;6. A possible question to ask is if their developmental profiles differ from those who exhibited typical speech and language skills at all ages.

Intervention research is needed in order to evaluate possible causal influence between variables and elucidate current theoretical understanding. Given current limitations in funding and provision of clinical services, an avenue for intervention research is the examination of relative effects in prioritizing lexical over phonological intervention on vocabulary growth and vice versa for children from each profile. For example, a parent-centred intervention program focused on lexical intervention has been reported to have a positive effect on LTs' productive phonology, including increased consonantal inventory and complex syllable structure (Girolametto, Pearce, & Weitzman, 1997). Specific intervention strategies to systematically elicit imitation of new and non-words (motor programming and programs) and its impact on children's vocabulary and expressive language abilities throughout development is a potential avenue for future research.

As discussed in chapter two, pre-schoolers' speech difficulties (regardless of their levels of severity) could impact on their later literacy development (Anthony et al., 2011; Holm et al., 2008; Larrivee & Catts, 1999; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004; Rvachew, 2007) and persist into the school years. Children with speech difficulties vary in their phonological awareness skills (Rvachew, 2007). Based on the results of the current study, it may be that young LTs who move on to evidence isolated phonological impairment were at a relatively lower risk for developing reading difficulties than those with comorbid phonological and language impairment (Nathan et al., 2004). More research is needed to facilitate increased efficiency in resource management and guide clinicians and parents in making informed choices regarding services for late-talking children and those diagnosed with language impairment. This

8.8 Conclusion

The current study has attempted to answer the call for longitudinal research on the relationship between phonology and the lexicon in young toddlers, especially late talkers. The developmental trajectories of phonology and the lexicon were tracked, and their relationships analysed over 18-month intervals when the children were 2;0, 3;6 and 5;0. In addition, potential underlying mechanisms affecting relationships were explored. The current study extends previous findings by adding the investigation of the role of phonology relative to phonological processing skills in accounting for the slower acquisition of words. Results support previous findings on the presence of a relationship between the developing phonological and lexical systems in late talking as in typically developing 2-year-olds, although delayed.

An interesting finding of the present research is that while each measure of phonological accuracy was significantly correlated to expressive language, they differed for each group in terms of the relative strength of association and influence across development with the important role of motor programming and motor program emphasised. The LTs in the current cohort are a heterogeneous group with varied profiles, based on their phonological and language performances that appeared to change along a predictable continuum with development. A unique finding was the emergence of a high proportion of LTs who was at a higher risk of having delayed phonological development than persisting language impairment by 5 years old.

The psycholinguistic approach has demonstrated that it can have important effects "in reshaping our thinking…" (Baker et al., 2001, p. 686) and can contribute to understanding the unfolding nature of late talking, and in particular how underlying impairments may interfere with development. Nonetheless, the Stackhouse and Well's (1997) model offers one way of interpreting the results. In keeping with the essence of this approach, results should be interpreted within a larger context in which young children acquire their ambient language and develop, incorporating other possible interpretations and findings from various fields of study as discussed.

APPENDICES

APPENDIX A. Human ethics approval

UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

HUMAN ETHICS COMMITTEE

Secretary, Lynda Griffioen
Email: human-ethics@canterbury.ac.nz

Ref: HEC 2011/121

14 January 2015

Professor Thomas Klee
Department of Communication Disorders
UNIVERSITY OF CANTERBURY

Dear Professor Klee

Thank you for your request for an amendment to your research proposal "Early factors in childhood communication disorders" as outlined in your letter dated 9 January 2015.

I am pleased to advise that this request has been considered and approved by the Human Ethics Committee.

Yours sincerely

Dr Lindsey MacDonald
Chair
University of Canterbury Human Ethics Committee

University of Canterbury Private Bag 4800, Christchurch 8140, New Zealand. www.canterbury.ac.nz

E 3

APPENDIX B. Information pack for parents: Time 1 and Time 3

Learning to Talk
Part 1

Information for parents/whānau

An invitation to participate in part 1 of a research project on children's early language development

Kia ora! Hello!
We would like to invite you to take part in a research project about children's early language development. Before deciding if you'd like to participate, please read through this information. If you have any questions about the project, feel free to get in touch with us by phone or email.

What is the purpose of the project?
Some children learn to talk quickly and some take their time. Many two-year-olds are joining words together in sentences while others are saying only a few words. Some children who start off slowly catch up over time, while others have ongoing problems with language. The purpose of this study is to explore the range of language abilities of young children in New Zealand and improve the way in which those with speech and language difficulties are identified.

What is involved?
The project will take place in two parts. In the first part, we are searching for children between 24 and 30 months of age. If your child will be in this age range between now and December 2012, you can participate! You need to fill in two questionnaires. One questionnaire is about your child's use of words and sentences. The other is about your family and your child's birth history. We need 1000 parents in the Canterbury region to complete these two questionnaires. Whether your child is talking a lot or has not yet begun to talk, we would like to hear from you.

In the second part of the project, we will invite around 200 of you to bring your child to the University of Canterbury, where a speech and language therapist will assess your child's speech, language, hearing and memory skills. There is another information sheet about that part of the study which you can request when you send back the questionnaires for part 1.

Even if you don't think you can commit the time to the second part of the project, we would appreciate it if you would fill out the two questionnaires needed for the first part of the project. This should take no more than 20 to 30 minutes and your involvement will end there.

Child's Name ____ Sex ____________

Birthdate ____________________ Age ____________* Today's Date ________________

** Please check your child is aged 2-2.5 years old at the time you fill in this questionnaire*

The MacArthur-Bates Communicative Development Inventory: Words & Sentences

New Zealand English Adaptation

PART 1 – WORDS CHILDREN USE

A. VOCABULARY CHECKLIST

Children understand many more words than they say. We are particularly interested in the words your child SAYS. Please go through the list and mark the words you have heard your child use. If your child uses a different pronunciation of a word (for example, "raffe" instead of "giraffe" or "sketti" for "spaghetti"), mark the word anyway. Remember that this is a "catalogue" of all the words that are used by many different children. Don't worry if your child only knows a few of these right now.

1. SOUND EFFECTS AND ANIMAL SOUNDS (12)

baa baa	O	meow	O	uh oh	O
choo choo	O	moo	O	vroom	O
cockadoodledoo	O	ouch	O	woof woof	O
grr	O	quack quack	O	yum yum	O

2. ANIMALS (Real or Toy) (42)

alligator	O	duck	O	owl	O
animal	O	elephant	O	penguin	O
ant	O	fish	O	pig	O
bear	O	frog	O	pony	O
bee	O	giraffe	O	possum	O
bird	O	goose	O	puppy	O
bunny	O	hen	O	rooster	O
butterfly	O	horse	O	sheep	O
cat	O	insect	O	teddybear	O
chicken	O	lamb	O	tiger	O
cow	O	lion	O	turkey	O
deer	O	monkey	O	turtle	O
dog	O	moose	O	wolf	O
donkey	O	mouse	O	zebra	O

3. VEHICLES (Real or Toy) (14)					
aeroplane	O	fire engine	O	tractor	O
bike	O	helicopter	O	train	O
boat	O	motor bike	O	tricycle	O
bus	O	pushchair*	O	truck	O
car	O	sled	O		

*or word used in your family: please add to Section F.

4. TOYS (18)					
ball	O	chalk	O	pencil	O
balloon	O	crayon	O	play dough	O
bat	O	doll	O	present	O
block	O	game	O	puzzle	O
book	O	glue	O	story	O
bubbles	O	pen	O	toy	O

5. FOOD AND DRINK (68)					
apple	O	fizzy drink	O	peas	O
banana	O	food	O	pizza	O
beans	O	gherkin	O	popcorn	O
biscuit	O	grapes	O	potato	O
bread	O	green beans	O	potato chip	O
butter	O	hamburger	O	pretzel	O
cake	O	ice	O	pudding	O
carrots	O	ice block	O	pumpkin	O
cereal	O	ice cream	O	raisin	O
cheerios	O	jam	O	salt	O
cheese	O	jelly	O	sandwich	O
chewing gum	O	juice	O	sauce	O
chicken	O	lollies	O	soup	O
chips	O	lollipop	O	spaghetti	O
chocolate	O	meat	O	strawberry	O
coffee	O	melon	O	toast	O
coke	O	milk	O	tomato sauce	O
corn	O	muffin	O	tuna	O
cracker	O	noodles	O	vanilla	O
doughnut	O	nuts	O	vitamins	O
drink	O	orange	O	water	O
egg	O	pancake	O	yogurt	O
fish	O	peanut butter	O		

6. CLOTHING (27)					
beads	O	jacket	O	shorts	O
belt	O	jeans	O	slipper	O
bib	O	jersey	O	sneaker	O
boots	O	nappy	O	snowsuit	O
button	O	necklace	O	sock	O
coat	O	pyjamas	O	tights	O
dress	O	scarf	O	trousers	O
gloves	O	shirt	O	underpants	O
hat	O	shoe	O	zip	O

11. PLACES TO GO (22)					
beach	O	home	O	playground	O
camping	O	house	O	school	O
church*	O	movie	O	shop	O
circus	O	outside	O	work	O
country	O	park	O	yard	O
downtown	O	party	O	zoo	O
farm	O	petrol station	O		
forest	O	picnic	O		

*or word used in your family: please add to Section F.

12. PEOPLE (29)					
aunt/auntie	O	daddy*	O	mummy*	O
baby	O	doctor	O	nurse	O
babysitter	O	fireman	O	people	O
babysitter's name	O	friend	O	person	O
boy	O	girl	O	pet's name	O
brother	O	grandma*	O	police	O
child	O	grandpa*	O	sister	O
child's own name	O	lady	O	teacher	O
clown	O	mailman	O	uncle	O
cowboy	O	man	O		

*or word used in your family: please add to Section F.

13. GAMES AND ROUTINES (24)					
bath	O	hi	O	please	O
breakfast	O	hello	O	shh/shush/hush	O
bye	O	lunch	O	shopping	O
call (on the phone)	O	nap	O	snack	O
dinner/tea	O	night night	O	thank you	O
give me five!	O	no	O	this little piggy	O
gonna get you!	O	patty cake	O	turn around	O
go potty	O	peekaboo	O	yes	O

14. ACTION WORDS (103)									
bite	O	drive	O	hug	O	read	O	swim	O
blow	O	drop	O	hurry	O	ride	O	swing	O
break	O	dry	O	jump	O	rip	O	take	O
bring	O	dump	O	kick	O	run	O	talk	O
build	O	eat	O	kiss	O	say	O	taste	O
bump	O	fall	O	knock	O	see	O	tear	O
buy	O	feed	O	lick	O	shake	O	think	O
carry	O	find	O	like	O	share	O	throw	O
catch	O	finish	O	listen	O	show	O	tickle	O
chase	O	fit	O	look	O	sing	O	touch	O
clap	O	fix	O	love	O	sit	O	wait	O
clean	O	get	O	make	O	skate	O	wake	O
climb	O	give	O	open	O	sleep	O	walk	O
close	O	go	O	paint	O	slide	O	wash	O
cook	O	hate	O	pick	O	smile	O	watch	O
cover	O	have	O	play	O	spill	O	wipe	O
cry	O	hear	O	pour	O	splash	O	wish	O
cut	O	help	O	pretend	O	stand	O	work	O
dance	O	hide	O	pull	O	stay	O	write	O
draw	O	hit	O	push	O	stop	O		
drink	O	hold	O	put	O	sweep	O		

15. DESCRIPTIVE WORDS (63)

allgone	O	full	O	orange	O
asleep	O	gentle	O	poor	O
awake	O	good	O	pretty	O
bad	O	green	O	quiet	O
better	O	happy	O	red	O
big	O	hard	O	sad	O
black	O	heavy	O	scared	O
blue	O	high	O	sick	O
broken	O	hot	O	sleepy	O
brown	O	hungry	O	slow	O
careful	O	hurt	O	soft	O
clean	O	last	O	sticky	O
cold	O	little	O	stuck	O
cute	O	long	O	thirsty	O
dark	O	loud	O	tiny	O
dirty	O	mad	O	tired	O
dry	O	naughty	O	wet	O
empty	O	new	O	white	O
fast	O	nice	O	windy	O
fine	O	noisy	O	yellow	O
first	O	old	O	yucky	O

16. WORDS ABOUT TIME (12)

after	O	morning	O	today	O
before	O	night	O	tomorrow	O
day	O	now	O	tonight	O
later	O	time	O	yesterday	O

17. PRONOUNS (25)

he	O	me	O	their	O	we	O
her	O	mine	O	them	O	you	O
hers	O	my	O	these	O	your	O
him	O	myself	O	they	O	yourself	O
his	O	our	O	this	O		
I	O	she	O	those	O		
it	O	that	O	us	O		

18. QUESTION WORDS (7)

how	O	when	O	which	O	why	O
what	O	where	O	who	O		

19. PREPOSITIONS AND LOCATIONS (26)

about	O	down	O	on top of	O
above	O	for	O	out	O
around	O	here	O	over	O
at	O	inside/in	O	there	O
away	O	into	O	to	O
back	O	next to	O	under	O
behind	O	of	O	up	O
beside	O	off	O	with	O
by	O	on	O		

20. QUANTIFIERS AND ARTICLES (17)

a	O	each	O	other	O
all	O	every	O	same	O
a lot	O	more	O	some	O
an	O	much	O	the	O
another	O	none	O	too	O
any	O	not	O		

21. HELPING VERBS (21)

am	O	does	O	need/ need to	O
are	O	don't	O	try/ try to	O
be	O	gonna/ going to	O	wanna/ want to	O
can	O	gotta/ got to	O	was	O
could	O	hafta/ have to	O	were	O
did/ did ya	O	is	O	will	O
do	O	lemme/ let me	O	would	O

22. CONNECTING WORDS (6)

and	O	but	O	so	O
because	O	if	O	then	O

B. HOW CHILDREN USE WORDS

	Not Yet	Sometimes	Often
1. Does your child ever talk about past events or people who are not present? For example, a child who saw a parade last week might later say parade, clown or band.	O	O	O
2. Does your child ever talk about something that's going to happen in the future, for example, saying "choo choo" or "aeroplane" before you leave the house for a trip, or saying "swing" when you are going to the park?	O	O	O
3. Does your child talk about objects that are not present such as asking about a missing or absent toy, referring to a pet out of view, or asking about someone not present?	O	O	O
4. Does your child understand if you ask for something that is not in the room, for example, by going to the bedroom to get a teddy bear when you say "where's the bear?"	O	O	O
5. Does your child ever pick up or point to an object and name an absent person to whom the object belongs? For example, a child might point to mummy's shoe and say "mummy".	O	O	O

PART II – SENTENCES AND GRAMMAR

A. WORD ENDINGS/PART I

	Not Yet	Sometimes	Often
1. To talk about more than one thing, we add an 's' to many words. Examples include cars (for more than one car), shoes, dogs and keys. Has your child begun to do this?	O	O	O
2. To talk about ownership, we add an "s", for example, Daddy's key, cat's dish and baby's bottle. Has your child begun to do this?	O	O	O
3. To talk about activities, we sometimes add 'ing' to verbs. Examples include looking, running and crying. Has your child begun to do this?	O	O	O
4. To talk about things that happened in the past, we often add 'ed' to the verb. Examples include kissed, opened and pushed. Has your child begun to do this?	O	O	O

B. WORD FORMS

Following are some other words children learn. Please mark any of these words that your child uses.

NOUNS

children	O	men	O	teeth	O
feet	O	mice	O		

VERBS

ate	O	fell	O	made	O
blew	O	flew	O	ran	O
bought	O	got	O	sat	O
broke	O	had	O	saw	O
came	O	heard	O	took	O
drank	O	held	O	went	O
drove	O	lost	O		

C. WORD ENDINGS/PART 2

Young children often place the wrong endings on words. For example, a child might say "Auntie goed home". Mistakes like this are often a sign of progress in language. In the following lists, please mark all the mistakes of this kind you have heard your child say recently.

NOUNS

blockses	O	mans	O	sockses	O
childrens	O	mens	O	teeths	O
childs	O	mices	O	toeses	O
feets	O	mouses	O	tooths	O
foots	O	shoeses	O		

VERBS

ated	O	comed	O	goed	O	ranned	O
blewed	O	doed	O	gotted	O	runned	O
blowed	O	dranked	O	haved	O	seed	O
bringed	O	drinked	O	heared	O	satted	O
buyed	O	eated	O	holded	O	sitted	O
breaked	O	falled	O	losed	O	taked	O
broked	O	flied	O	losted	O	wented	O
camed	O	getted	O	maked	O		

HAS YOUR CHILD BEGUN TO COMBINE WORDS YET, SUCH AS "NOTHER CRACKER", OR "DOGGIE BITE"?

O Not Yet   O Sometimes   O Often

IF YOU ANSWERED NOT YET, PLEASE STOP HERE. IF YOU ANSWERED SOMETIMES OR OFTEN, PLEASE CONTINUE.

D. EXAMPLES: Please list three of the longest sentences you have heard your child say recently.

1. ______________________________

2. ______________________________

3. ______________________________

E. COMPLEXITY

In each of the following pairs, please mark the one that sounds MOST like the way your child talks right now. If your child is saying sentences even longer or more complicated than the two provided, just pick the second one.

1. Two shoe. O
   Two shoes. O
2. Two foot. O
   Two feet. O
3. Daddy car. O
   Daddy's car. O
4. (Talking about something happening right now.)
   Cat sleep. O
   Cat sleeping. O
5. (Talking about something happening right now.)
   I make tower. O
   I making tower. O
6. (Talking about something that already happened.)
   I fall down. O
   I fell down. O
7. More biscuit! O
   More biscuits! O
8. These my tooth. O
   These my teeth. O
9. Baby blanket. O
   Baby's blanket. O
10. (Talking about something that already happened.)
    Doggie kiss me. O
    Doggie kissed me. O
11. (Talking about something that already happened.)
    Daddy pick me up. O
    Daddy picked me up. O
12. (Talking about something that already happened.)
    Doggie go away. O
    Doggie went away. O
13. Doggie table. O
    Doggie on table. O
14. That my truck. O
    That's my truck. O
15. Baby crying. O
    Baby is crying. O
16. You fix it? O
    Can you fix it? O
17. Read me story, Mummy. O
    Read me a story, Mummy. O
18. No wash dolly. O
    Don't wash dolly. O
19. Want more juice. O
    Want juice in there. O
20. There a cat. O
    There's a cat. O
21. Go bye-bye. O
    Wanna go bye-bye. O
22. Where Mummy go? O
    Where did Mummy go? O
23. Coffee hot. O
    That coffee hot. O
24. I no do it. O
    I can't do it. O
25. I like read stories. O
    I like to read stories. O
26. Don't read book. O
    Don't want you read that book. O
27. Turn on light. O
    Turn on the light so I can see. O
28. I want that. O
    I want that one you got. O
29. Want biscuits. O
    Want biscuits and milk. O
30. Biscuit Mummy. O
    Biscuit for Mummy. O
31. Baby want eat. O
    Baby want to eat. O
32. Lookit me! O
    Lookin me dancing! O
33. Lookit! O
    Lookit what I got! O
34. Where's my dolly? O
    Where's my dolly name Sam? O
35. We made this. O
    Me and Paul made this. O
36. I sing song. O
    I sing song for you. O
37. Baby crying. O
    Baby crying cuz she's sad. O

F. OTHER COMMENTS/ other words your child says:

THANK YOU FOR COMPLETING THIS.

Consent Form

Learning to Talk (part 1)

I have read and understood the information that was given to me about the research project named above. I have had a chance to ask questions and have had them answered. I understand that my participation in this project is voluntary. I understand that the information you collect from me will remain confidential and will be securely stored at the university. I understand that any presentations or publications resulting from this project will not refer to me or anyone in my family by name. I understand that this project has been reviewed ***and approved*** by the University of Canterbury Human Ethics Committee. On this basis, I agree to participate in this research project.

MY CHILD'S NAME (please print): ....

MY NAME (please print): ....

My Signature: ....

Date: ....

Address: ....

....

- ❑ Feel free to contact me about participating in part 2 of this project. I understand that I am under no obligation to participate.
- ❑ I would like you to send me a brief summary of your findings when the study is complete. Please contact me by:
  - ❑ Email ______________________________
  - ❑ Cell phone ______________________________
  - ❑ Landline ______________________________
  - ❑ Post

Main Researcher:
Professor Thomas Klee
Email: ChildLanguageCentre@canterbury.ac.nz
Phone: 03 364 2987 ext. 8501

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Consent Form

Early Factors in Childhood Communication Disorders (part 2)

You may cross out any of the following statements you do not agree with:

1. I have read and understood the information given to me about the research project named above. I have had a chance to ask questions and have had them answered. I understand that my child's and my participation in this project are voluntary and that we are free to withdraw at any time without giving a reason. I understand that the sessions will be video and audio recorded. I understand that the information you collect from us will remain confidential and will be securely stored at the university. I understand that any presentations or publications resulting from this project will not refer to us by name. I understand that this project has been reviewed ***and approved*** by the University of Canterbury Human Ethics Committee. On this basis, my child (named below) and I agree to participate in this research project.

2. I agree to also let the researchers use the audio-video recording for **teaching purposes** at the university with the understanding that you will not refer to us by name.

3. I agree to also let the researchers use the audio-video recording at **research conferences** with the understanding that you will not refer to us by name.

MY CHILD'S NAME (please print): ....

MY NAME (please print): ....

My Signature: ....

Date: ....

I may be contacted by:

- ❑ Email ______________________________
- ❑ Cell phone ______________________________
- ❑ Landline ______________________________
- ❑ Post ______________________________

____

❑ I would like you to send me a brief summary of your findings when the study is complete.

Main Researcher: Professor Thomas Klee, Email: ChildLanguageCentre@canterbury.ac.nz, Phone: 03 364 2987 ext. 8501

University of Canterbury Private Bag 4800, Christchurch 8140, New Zealand. **www.canterbury.ac.nz**

APPENDIX C. Information pack for parents: Time 4

Learning to Talk

Information for parents/whānau

An invitation to participate in part 3 of the research project

The research team: Professor Thomas Klee, Professor Stephanie Stokes; Hamimah Ahmat, Daniela Buehler & Doreen Hansmann (PhD students)

Address: Child Language Centre | Te Reo o te Tamaiti
7 Creyke Road, Ilam, Christchurch 8041
Phone: for Hamimah, call 364 2987 ext. 7161
for Daniela or Doreen, call 364 2987 ext. 8193
Email: ChildLanguageCentre@canterbury.ac.nz
Website: www.cmds.canterbury.ac.nz/clc/

Kia ora! Hello!

You and your child took part in the **Learning to Talk** research project when they were 2 and again when they were coming up to age 4. A total of 168 families participated at age 2 and 155 returned at age 4 - a great success! We would now like to invite you and your child back for two more visits - if you are interested - now that your child is 5 years old. This will give us the opportunity to track children's language development for a full 3 years and give us further insight into how children's speech and language develops. During these two visits, we will assess your child's language, hearing and memory skills and engage your child in a task that will measure their brain activity. We hope you will consider participating in this next phase of the research project.

Before you decide if you want to participate, please take time to read this leaflet. It's important you know why the research is being done and what it will involve. Feel free to ask us if there is anything you are not sure about or would like more information about. We'd be happy to answer any questions you have. Our contact details are on the front page.

What is the purpose of the project?

Children vary in how quickly they develop speech and language skills. Some start off slowly and then catch up with others their age, while others have persisting difficulties throughout childhood. The purpose of this study is to help us figure out what we should look out for in 2- and 3- year olds in order to better understand long-term developmental outcomes. This will help inform parents and professionals about when to be concerned about their child's speech and language abilities.

What is involved?

We would like to see your child for an assessment at the Child Language Centre about 18 months after your last visit. Since your child may now be in school, we can arrange visits after school or on Saturday - at your convenience.

What will happen to my child if we take part?

You will need to make two visits to the Child Language Centre, at 7 Creyke Road in Ilam, with your child. The visits will be scheduled a week or two apart and will probably last about 1.5 hours each, or slightly longer.

During your visits, your child will be seen by several speech and language therapists who are working on their PhD. Daniela, Doreen and Hamimah will do some short tasks with your child to assess their speech and language skills. Your child's hearing will be tested with an instrument which is placed in your child's ear briefly. This doesn't hurt and only takes a few minutes. This will all be video-recorded. If your child is unhappy and wants to stop or take a break at any time, this is okay. You will be there with them all the time to see what is happening. We will also ask you to complete three, short written questionnaires at home and mail them back to us in a postage-free envelope.

What are the benefits for us?

Your child will receive another free book as a token of our appreciation. You will receive a $20 Westfield voucher and a $10 petrol or taxi voucher after your 2nd visit. We think your child will enjoy coming to see us, as everything we do is fun and child friendly. You will find it interesting to see where your child is at with their talking.

If you have any concerns about your child's speech, you can talk about them with us. We can send you the results from the assessments if you want them. There aren't any risks to you or your child as a result of participating in this study.

What if I change my mind?

You can pull out of the project at any time and you don't have to say why.

What will happen to the results of the project?

We will write up the results and share them with people who work with children across the world. Doreen, Hamimah and Daniela will also write up their part of the project as a doctoral thesis, which will be available through the University of Canterbury library.

Will my child's name be made public?

No, your child's name won't appear in any publications. Your names and contact details will be noted at the start, but then every child will be given a number, so only the researchers will know which child has which results. The information we have on your child will be kept in secure locked cabinets and secure computer files. Only people working on the project will have access to this information. Videos taken may be used for teaching purposes or at conferences only if you give permission.

Other information:

The project has been reviewed and approved by the University of Canterbury Human Ethics Committee (Dr Lindsey MacDonald, Committee Chair; Lynda Griffioen, Secretary, phone 364 2987 ext. 45588, email human-ethics@canterbury.ac.nz)

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Consent Form

Learning to Talk research study (Age 5)

You may cross out any of the following statements you do not agree with:

1. I have read and understood the information given to me about the research project named above. I have had a chance to ask questions and have had them answered. I understand that my child's and my participation in this project are voluntary and that we are free to withdraw at any time without giving a reason. I understand that the sessions will be video and audio recorded. I understand that the information you collect from us will remain confidential and will be securely stored at the university. I understand that any presentations or publications resulting from this project will not refer to us by name. I understand that this project has been reviewed ***and approved*** by the University of Canterbury Human Ethics Committee. On this basis, my child (named below) and I agree to participate in this research project.

2. I agree to also let the researchers use the audio-video recording for **teaching purposes** at the university with the understanding that you will not refer to us by name.

3. I agree to also let the researchers use the audio-video recording at **research conferences** with the understanding that you will not refer to us by name.

MY CHILD'S NAME (please print): ....

MY NAME (please print): ....

My Signature: ....

Date: ....

I may be contacted by:

- ☐ Email ____________________________
- ☐ Cell phone ____________________________
- ☐ Landline ____________________________
- ☐ Post ____________________________

☐ I would like you to send me a brief summary of your findings when the study is complete.

Main Researcher: Professor Thomas Klee, Email: ChildLanguageCentre@canterbury.ac.nz,
Phone: 03 364 2987 ext. 8501
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